A Water Quality Monitoring Strategy for the Commonwealth of Massachusetts

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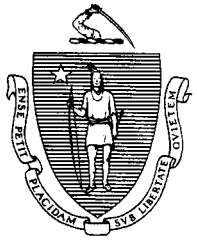

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Executive Summary

Introduction

The Bureau of Resource Protection has developed this document "*A Water Quality Monitoring Strategy for the Commonwealth of Massachusetts* " (the Monitoring Strategy) in accordance with applicable elements and schedules contained in the EPA and State Performance Partnership Agreement (PPA). Major components of the proposed monitoring program fulfill requirements of the Federal Clean Water Act (CWA) and the Federal Safe Drinking Water Act, and are consistent with design and implementation approaches suggested by the EPA in a guidance document entitled *Elements of a State Water Monitoring and Assessment Program* (March, 2003). The EPA acknowledges that the current status of state monitoring programs varies with respect to satisfactorily meeting all of the program elements called for in the guidance, and personnel and other resources are a significant constraint for all states. Therefore, EPA has provided these elements as goals to be achieved over the next ten years and the Monitoring Strategy reflects this time frame.

Major Monitoring Goals and Design Elements

The ultimate goal of the Department is to implement a comprehensive monitoring program that serves all water quality management needs, and addresses streams, rivers, lakes, reservoirs, wetlands, estuaries, coastal areas, and groundwater. This document describes the collection and use of monitoring data from all of these water body types, with exception of wetlands. Before wetlands monitoring programs are established, criteria with which to assess designated use impairment and other impacts must be developed. One element of the strategy is to add a wetlands ecologist to the Department's Division of Watershed Management staff to develop these criteria and then design monitoring programs accordingly. The proposed monitoring elements incorporate a number of different design components such as the assessment of designated uses, fixed-station networks, intensive and screening-level targeted monitoring, and randomization. Furthermore, these designs encompass rotating watershed monitoring cycles, continuous year-round sampling, and non-rotating priority-driven schedules.

Major goals of the Monitoring Strategy and the corresponding monitoring program elements designed to meet those goals are presented in the table below:

MONITORING GOALS	MONITORING DESIGN ELEMENTS
1) Determine whether waters are meeting Water Quality Standards	• Five-year Rotating Watershed Monitoring for Use Assessments *(existing)* • Targeted monitoring to assess bioaccumulation *(existing)* • Targeted monitoring of lakes *(proposed)* • Probabilistic Sampling Network *(proposed)*
2) Determine water quality trends and contaminant loadings	• Continuous fixed-site monitoring network *(proposed)*
3) Implement pollution control strategies (TMDLs and Clean-up Plans)	• Targeted monitoring to support TMDL Program *(existing and proposed)* • Targeted monitoring of lakes *(existing)* • Targeted monitoring to locate sources of bacterial contamination *(pilot)*
4) Identify emerging issues and develop policies and standards	• Targeted monitoring for criteria development *(existing)*
5) Measure program or project effectiveness	• Project-specific, targeted monitoring

6) Improve the protection of public health and the environment by reducing the risk of drinking contaminated water	• Surface Water Assessment Program • Probabilistic monitoring of groundwater

The highest priority monitoring elements are aimed at knowing the condition of Massachusetts' waters, finding pollution sources (as related to TMDLs), and developing strategies for restoring impaired waters. "Knowing the waters" is the fundamental element that triggers other monitoring programs aimed at water quality management and provides the information needed to develop the *Integrated List of Waters*. Therefore, the rotating watershed monitoring plan and targeted monitoring to identify pollution sources and support TMDLs and other clean-up activities receives the highest priorities and are already being carried out to the extent that existing resources allow. The most immediate needs, in order to more fully meet the highest priority objectives, include two additional benthic biologists, one additional microbiologist, two data management specialists, and six TMDL monitoring personnel.

Monitoring to detect trends and loadings was assigned the next highest priority, and implementation is proposed within two years of the Monitoring Strategy approval. Finally, while probabilistic monitoring designs are useful for drawing inferences on the status of waters state-wide, they are not as helpful for identifying site-specific problem areas and focusing remedial actions, and consequently are given the lowest priority. For that reason the Monitoring Strategy specifies a five-year implementation schedule for lakes and ponds and ten years for rivers and coastal waters.

There are several themes that pervade all of the monitoring elements proposed in the Monitoring Strategy. All of the monitoring elements have been designed to yield data and information that will result in better management decisions, and data will be shared with other programs, both within the Department as well as in other agencies, for use in their work. Finally, the creation of partnerships, such as the involvement of community partners in drinking water protection and the use of data from citizen monitoring groups and other external sources, for assessment purposes, is promoted in the Monitoring Strategy.

General Support and Infrastructure Planning

Human and monetary resources will be needed to implement new monitoring programs, and to continue existing programs. The following table provides a summary of the total annual resources needed to implement the entire Monitoring Strategy over a ten-year period along with the current program shortfalls (italicized in parentheses).

RESOURCE	**ANNUAL PERSONNEL (FTE)***	**ANNUAL COST***
Assessment and Targeted Monitoring		
Water quality monitoring staff	14.0 *(10.0)*	$1,190,000 *($850,000)*
Benthic biologists	5.0 *(2.0)*	$425,000 *($170,000)*
Microbiologists	3.0 *(2.0)*	$255,000 *($170,000)*
Fish biologists	3.0 *(1.0)*	$255,000 *($85,000)*
Wetlands ecologist	1.0 *(1.0)*	$85,000 *($85,000)*
Volunteer monitor liaison	1.0 *(1.0)*	$85,000 *($85,000)*
Seasonal field staff	3.0	$255,000
TMDL monitoring staff	6.0 *(6.0)*	$510,000 *($510,000)*
TMDL monitoring equipment	--	$192,360 *($192,360)* **
Total personnel and cost	**36.0 *(23.0)***	**$3,252,360 *($2,147,360)***

Continuous Fixed-site Monitoring for Contaminant Load Trends		
Monitoring staff	2.0 *(2.0)*	$170,000 *($170,000)*
Total cost	--	**$170,000 *($170,000)***
General Monitoring Support		
Field technical support staff	2.0 *(1.0)*	$170,000 *($85,000)*
Data management staff	7.0 *(4.5)*	$595,000 *($382,500)*
QA/QC staff/statistician	3.0 *(2.0)*	$255,000 *($170,000)*
GIS staff	0.5	$42,500
Total personnel	**12.5 *(7.5)***	**$1,062,500 *($637,500)***
Monitoring Equip/Supplies	--	$40,000 *($10,000)*
Laboratory support (8 FTE)	--	$680,000 *($595,000)*
Seasonal/ongoing laboratory	--	$75,000
Total cost	--	**$1,857,500 *($1,242,500)***
Drinking Water Program		
Drinking Water staff	0.6 *(0.6)*	$51,000 *($51,000)*
Laboratory services	--	$1,516,568 *($1,516,568)*
GRAND TOTAL	**51.1 FTE *(33.1 FTE)***	**$6,847,428 *($5,127,428)***

* Existing program shortfalls are provided in italics and parentheses.

** Costs for vehicles, flow meters, temperature meters, current meters, bacterial analyses, and water chemistry analyses.

Note:

1) Above estimates do NOT include resources for marine monitoring (assumes CZM and DMF lead)

2) Above estimates do not include office equipment and office space.

With a total shortfall approximating twice the currently available resources, it is clear that the Monitoring Strategy will need to be implemented in phases as new funding becomes available. The following table summarizes by program element the long-term and immediate personnel resources needed to implement the plan.

PROGRAM ELEMENT	PRIORITY	LONG-TERM NEED (FTE)/(dollars)	EXISTING STAFF (FTE)	EXISTING STAFF (% of need)	IMMEDIATE NEED (FTE)/(dollars)
Assessment Monitoring	High	27 ($2,295,000)	13	48%	7 ($595,000)
TMDL Monitoring	High	6 ($510,000)	0	0%	6 ($510,000)
Fixed-site Monitoring	Medium	2 ($170,000)	0	0%	0
Probabilistic Monitoring	Low	3 ($ 255,000)	0	0%	0
Support Staff	High	12.5 ($1,062,500)	5	40%	2 ($170,000)
Drinking Water	Medium	0.6 ($51,000)	0	0%	0
TOTAL	***--***	***51.1 ($4,343,000)***	***18***	***36%***	***15 ($1,275,000)***

The Monitoring Strategy provides a template for focusing new resources on priority monitoring elements, and final completion of the approved Monitoring Strategy will enhance Massachusetts' eligibility for future EPA grants aimed at strengthening state monitoring and assessment programs. The Department will continue to explore new and innovative ways to secure monetary and human resources to implement the Monitoring Strategy, including building partnerships with other agencies and outside groups. Meanwhile, monitoring efforts over the next couple of years will continue to be focused on the rotating watershed cycle for assessments and targeted monitoring to support the TMDL Program. With the limited resources currently available, not all watersheds in each phase of the five-year schedule will be monitored.

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Introduction

The Massachusetts Department of Environmental Protection (The Department) is tasked with protecting and managing water resources throughout the Commonwealth. It is important to base water resource protection on information and data that allow prioritization of the issues (to assure that the Department is addressing the most important issues), to allow proactive decision-making on existing and emerging issues, and to enable evaluations of the effectiveness of the Department's water resource protection programs. To meet these goals the Department must develop a base of data large enough to characterize the extent of environmental contamination and set prioritlies for developing standards, improve the selection process for various grant programs, and to support the development of pollution control strategies. To accomplish this overall goal, and to address a wide variety of water quality-related objectives, the Department has developed a multifaceted monitoring strategy that includes monitoring elements, data analysis, reporting, and use of the data for management decisions. Major components of the monitoring program fulfill requirements of the Federal Clean Water Act (CWA) and the Federal Safe Drinking Water Act, and are consistent with design and implementation approaches suggested by the EPA (2003).

For drinking water purposes, the Department is responsible for ensuring that the water delivered by public water systems in Massachusetts meets national and state standards. As EPA's Primacy Agent for the federal Safe Drinking Water Act, our Drinking Water Program protects public health by regulating water quality monitoring, new source approvals, water supply treatment and distribution, source protection, emergency preparedness, and reporting of water quality data.

The Department also coordinates with the Massachusetts Water Resources Commission and the Department of Conservation & Recreation's Division of Water Resources in regulating the quantity of water used for drinking water supplies and in promoting water conservation.

For drinking water purposes, the Department administers and enforces:

- The Safe Drinking Water Act of 1974 (42 U.S.C. 300f *et seq*.) as amended and associated federal regulations (40 CFR 141-144);
- Massachusetts General Laws Chapter 111, Sections 159 and 1-0, and associated state regulations at 310 CMR 2.00-24.00, 27.00 and 28.00; and
- The Water Management Act, MGL Chapter 21G and associated regulations at 310 CMR 36.00.

As required by 1996 amendments to the Safe Drinking Water Act, DWP developed a Source Water Assessment and Protection Program (SWAP) and assessed the susceptibility to contamination of 3200 sources of drinking water in Massachusetts within 1684 public water systems. The assessment reports developed, and land use information mapped, as part of this effort will allow DWP to more effectively target the successful source protection work that they have conducted for many years.

Nineteen percent (19%) of the State is overlain by water supply protection areas. This protection also indirectly benefits over 550,000 residents who withdraw their drinking water from private wells.

The work conducted by this Monitoring Plan will link Clean Water Act and Safe Drinking Water Act information to better protect public health and the environment.

The CWA Section 106(e)(1) and 40 CFR Part 35.168(a) provide that the EPA award Section 106 funds to a State only if that State has provided for, or is carrying out as part of its program,

the establishment and operation of appropriate devices, methods, systems, and procedures necessary to monitor and to compile and analyze data on the quality of navigable waters in the State, and has made provisions for annually updating the data and including them in the Section 305(b) report. Because EPA guidance for meeting these objectives has not been clearly defined in the past, there is a lot of variability in existing State programs. Consequently, the EPA now recommends ten basic elements of a State water resource monitoring program to provide consistency and to serve as a tool to help the EPA and the States determine whether a monitoring program meets the prerequisites of CWA Section 106(e)(1). The ten elements (EPA, 2003), and a brief description of each, are as follows:

A. Monitoring Program Strategy
A comprehensive monitoring program strategy that serves Massachusetts water quality management needs and addresses all State waters, including streams, rivers, lakes, reservoirs, estuaries, coastal areas, wetlands, and groundwater. The monitoring program strategy is a long-term implementation plan that the EPA believes should be upgraded to include all of the elements described below within the next 10 years.

B. Monitoring Objectives
Monitoring objectives, identified by the State, that are critical to the design of a monitoring program that is efficient and effective in generating data that serve management decision needs including, but not limited to, Clean Water Act goals.

C. Monitoring Design
The strategy must have an approach and rationale for selection of monitoring designs and sample sites that best serve the monitoring objectives. The monitoring program ultimately will integrate several monitoring designs (e.g., fixed station, intensive and screening-level monitoring, rotating basin, etc.) to meet the full range of decision needs.

D. Core and Supplemental Water Quality Indicators
Core indicators are selected to represent each applicable designated use, plus supplemental indicators selected according to site-specific or project-specific decision criteria. Core indicators can be used routinely to assess attainment with applicable water quality standards throughout the State. Supplemental indicators are used when there is a reasonable expectation that a specific pollutant may be present in a watershed, when core indicators indicate impairment, or to support a special study such as screening for potential pollutants of concern.

E. Quality Assurance
Quality management plans and quality assurance program/project plans are developed and implemented (maintained and peer reviewed in accordance with EPA policy) to ensure the scientific validity of monitoring and laboratory activities, and to ensure that State reporting requirements are met.

F. Data Management
An electronic data system is developed and utilized for water quality, fish tissue, toxicity, sediment chemistry, habitat, biological data, with timely data entry (following appropriate metadata and State/Federal geo-locational standards) and public access.

G. Data Analysis/Assessment
The State has a methodology for assessing attainment of water quality standards based on analysis of various types of data (chemical, physical, biological, land use) from various sources, for all waterbody types and all State waters. The methodology includes criteria for compiling, analyzing, and integrating all readily available and existing information (e.g., volunteer monitoring data, discharge monitoring reports).

H. Reporting
The State produces timely and complete water quality reports and lists called for under Sections 305(b), 303(d), 314, and 319 of the Clean Water Act and Section 406 of the Beaches Act.

I. Programmatic Evaluation
The State, in consultation with its EPA Region, conducts periodic reviews of each aspect of its monitoring program to determine how well the program serves its water quality decision needs for all State waters, including all waterbody types.

J. General Support and Infrastructure Planning
Current and future resource requirements (funding, staff, training, laboratory resources) for fully implementing the monitoring program strategy.

This document describes in detail the elements of the Massachusetts water monitoring program that are required to demonstrate that the program meets the prerequisites of Section 106(e)(1) of the Clean Water Act .

In 2001, The U.S. Geological Survey (USGS) worked with the Department to design a long-term water quality monitoring program for Massachusetts. The program design was guided by the information needs of the EPA and the Department, which include mandates of the CWA, and included input from many organizations involved with water quality monitoring in the Commonwealth. The monitoring program presented here borrows heavily from the USGS model.

Because of the limited resources available across all State agencies, it is important that the Department's monitoring plan does not duplicate the efforts of other monitoring programs, and that specific efforts are made to insure that data are shared between agencies. To this end, an effort was made to assess the data collection activities of other organizations. The results of this effort, which are summarized in the Appendix, indicate that ongoing monitoring programs by State agencies include (1) the DEP's river and lake physicochemical studies, fish-toxics monitoring, benthic macroinvertebrate and other biomonitoring efforts, (2) lake monitoring by the Department of Conservation and Recreation (DCR) in state parks, (3) reservoir, reservoir tributary, and coastal river sampling for bacteria and water-chemistry by the Metropolitan District Commission (now part of DCR) and the Massachusetts Water Resources Authority (MWRA), (4) coastal water monitoring for bacteria and physical components by the Division of Marine Fisheries (DMF) and fish community surveys by the Division of Fisheries and Wildlife of the Department of Fish and Game (DFG), (6) extensive water quality monitoring of Massachusetts Bay and Boston Harbor by the MWRA, (7) ground-water monitoring for highway-runoff contaminants by the Massachusetts Highway Department, and (8) Massachusetts Coastal Zone Management's (MCZM) programs on: salt marsh integrity, invasive species, sea grasses, probabilistic monitoring, and water quality degradation in coastal waters, and (9) diverse monitoring activities of many local volunteer groups. In addition, the Department funds extensive monitoring through grants, including the monitoring of approximately 90 tidal embayments in the southeastern potion of the State as part of the Massachusetts Estuaries Project. Finally, on a case-by-case basis, the Department may obtain ambient water quality monitoring data from NPDES permitees.

Many of these activities provide data for components of the statewide monitoring program, but none has the monitoring approach, geographic coverage, sampling density, or suite of sampling variables that would meet all the information needs of the Department and the EPA. Furthermore, most of these programs collect data for narrowly focused objectives that may differ substantially from those of the Department, thus limiting their potential for use in its water quality management programs. The review of ongoing monitoring programs in Massachusetts revealed that the Department has the mandate and organizational framework for administering

a comprehensive monitoring program in accordance with the requirements of the CWA as well as meeting it's own data needs. Nonetheless, data from these other sources will continue to be used, where appropriate, for assessment purposes.

II. Monitoring Program Strategy

The ultimate goal of the Department is to implement a comprehensive monitoring program (status/assessment, trends and flows, and targeted) that serves all water quality management needs, and addresses streams, rivers, lakes, reservoirs, estuaries, coastal areas, wetlands, and groundwater. This document describes the collection and use of monitoring data from all of these water body types, with exception of wetlands. Before wetlands monitoring programs are established, criteria with which to assess designated use impairment and other impacts must be developed. One element of the strategy is to add a wetlands ecologist to the Department's Division of Watershed Management staff to develop these criteria and then design monitoring programs accordingly. The strategy includes significant efforts by the Department to supplement its programs with volunteer monitoring data, as well as data from other State and Federal monitoring programs. Because of resource limitations, the full program will not be fully implemented over a short period of time. Therefore, the strategy for implementing the monitoring program includes the prioritization of programs and program elements.

The overall monitoring program will utilize a combination of deterministically and probabilistically derived sampling networks best suited to meet state monitoring goals and objectives. These monitoring elements incorporate a number of different design components such as the assessment of designated uses, fixed-station networks, intensive and screening-level targeted monitoring, and randomization. Furthermore, these designs encompass both rotating watershed monitoring cycles as well as non-rotating priority-driven schedules. The strategy is to incorporate new components into the existing program elements over the next ten years.

The five-year rotating watershed assessment program is currently the primary means of meeting the CWA objective related to assessing the status of designated uses. Requirements for the monitoring program designed to support watershed assessments, reflecting CWA mandates, are that it be statewide in scale, comprehensive (all water bodies in the Commonwealth are assessed), and repeated at regular intervals. Another requirement is that the program lead to improvements in the federal 305(b) assessment process, by increasing the number of stream miles and lake acres assessed and reducing the historical bias toward problem areas. This expanded coverage could be achieved by supplementing the existing deterministic assessment monitoring program with a probabilistic sampling design aimed at wadeable streams and lakes. It is projected that some probabilistic design elements will be incorporated within the next five years, and a completed probabilistic program will be finalized within five more years.

Continuous, fixed-site monitoring is proposed to provide information and data pertaining to loads of contaminants carried by major river systems at strategic locations within Massachusetts. This information would be gathered at the mouths of rivers to quantify loads delivered to coastal waters, such as Boston Harbor, and major inland waterways, such as the Connecticut River. Information is also needed at State boundaries to determine contaminant loads entering and leaving Massachusetts. The USGS (2001) has recommended an approach utilizing a network of approximately twenty fixed sites. Over the long term, the data could be used to assess trends in flow and pollutant loadings. This program could be implemented within two years.

Growing emphasis is being placed on targeted monitoring aimed at identifying causes and sources of impairments, and for developing and implementing control strategies, such as

TMDLs, NPDES permits, and Best Management Practices (BMPs). Furthermore, targeted monitoring may provide data to define new and emerging issues or to support the development of water quality standards and policies. Currently the Department performs targeted monitoring to assess bioaccumulation and to derive TMDLs for lakes. Targeted monitoring will be expanded to include the identification of contaminant sources (including industrial and municipal wastewater treatment facility effluent sampling), determination of background or existing water quality conditions needed for the issuance of discharge permits, wastewater treatment facility improvements, implementation of BMPs for stormwater control, or assessing and documenting habitat loss or alteration. A pilot program, initiated in 2004, was established by the Department to formulate and implement protocols for locating sources of bacteria. However, the conceptual framework developed for bacterial sources will be modified to identify sources of other contaminants. The expanded source location identification program will be implemented within five years.

III. Monitoring Objectives

The identification of monitoring objectives is a critical first step in designing a monitoring program that is efficient and effective in generating data that support important water quality management decisions. The monitoring program for Massachusetts is designed to provide data and information from streams, rivers, lakes, reservoirs, estuaries, coastal areas, wetlands, and groundwater to support the following major objectives:

1) Assess the Status or Condition of Massachusetts' Waters – This objective is to perform periodic state-wide and watershed-based assessments of the water-quality status (relative to the attainment of beneficial uses as designated in the Surface Water Quality Standards) of the Commonwealth's surface waters, as required by Section 305(b) of the CWA. These assessments should support the development of the Section 303(d) List of Impaired Waters and should identify causes and sources of those impairments. This objective will ultimately be met by establishing statewide "continuous" sampling (multiple samples per year, every year) at fixed stations, in conjunction with more comprehensive assessment-related sampling within each watershed on a 5-year, rotating basis.

2) Determine Water Quality Trends and Contaminant Loadings – This objective is to determine loads of contaminants carried by major river systems in Massachusetts at strategic locations, such as at the mouths of rivers and at state boundaries (utilizing some or all of the fixed stations utilized in status monitoring program described above), and to determine long-term trends in concentrations and loads of contaminants.

3) Implement Pollution Control Strategies (Clean-up Plans) – This objective is to identify sources of pollution and to develop and implement measures for controlling them that include, but are not limited to, the derivation of Total Maximum Daily Loads (TMDLs), allocation of pollutant loads to point and nonpoint sources, issuance of NPDES wastewater discharge permits, and focusing Section 319 Grants to ameliorate nonpoint pollution.

4) Identify Emerging Issues and Develop Policies and Standards – This objective is to identify new and emerging water quality issues and problems and to conduct short-term research directed towards the establishment or revision of water quality policies and standards. Monitoring to meet this objective may be triggered by the results of other monitoring programs.

5) Measuring Program or Project Effectiveness – This objective is to evaluate the effectiveness of water quality management projects or programs. This may involve measuring the success of individual pollution control practices at the local level, such as the effectiveness of implementing a TMDL Best Management Practices (BMP) for the control of nonpoint pollution at a particular

site, or it could be a comprehensive assessment of an entire system of control measures for improving water quality such as the institution of a state-wide policy or permitting program.

For drinking water purposes, the Department has the following objectives:
6) Improve the protection of public health and the environment by reducing the risk of drinking contaminated water. – This objective will be achieved through:

- finding CWA actual contamination by linking monitoring to SDWA SWAP potential contaminants information (identify locations of public water systems and associated problem areas based on SWAP database);
- maintaining or improving source water quality;
- allowing for more effective filtration and disinfection, thereby reducing costs, at reservoirs and certain ground water sources.
- Identifying and tracking water quality problems before they impact drinking water sources;
- developing a better understanding of flow issues related to water quantity;
- improving emergency preparedness;
- better targeting protection, planning and outreach efforts;
- gathering information on emerging issues in drinking water; and
- helping to protect private wells.

7) Involve community partners in drinking water protection. – This will be accomplished by:

- sharing monitoring results with public water systems (pws) and encouraging greater involvement of suppliers in proactive monitoring efforts;
- allowing pws more effective participation in the TMDL process;
- allowing for better contingency and emergency preparedness among communities;
- make effective use of the work of local watershed teams or committees;
- distributing monitoring data to watershed organizations that are capable of doing implementation projects.

8) Use information obtained through the Monitoring Plan to make better management decisions. – This will be done by:

- allowing for more proactive decision-making about existing and emerging issues;
- providing a larger base of data to characterize the extent of environmental contamination and set priorities for the development of health-based standards;
- supporting the evaluation of program effectiveness;
- supporting existing programs related to stream flow and water quality; and
- improving the selection process to award State Revolving Fund (SRF) grant funding for drinking water improvement projects.

9) Make monitoring information available to other programs within the Department and other state agencies for use in their work.

For example, the Department of Agricultural Resources (DAR) EQUIP grants, which prioritize the protection of drinking water sources, will now target nutrient, pathogen, pesticide and sediment removal projects in Massachusetts impaired waters.

IV. Core and Supplemental Water Quality Indicators

EPA guidance calls for the State monitoring program to include “a core set of baseline indicators selected to represent each applicable designated use, plus supplementary indicators selected according to site-specific or project-specific decision criteria.” These indicators or

variables (e.g., water quality parameters) include physical/habitat, chemical/toxicological, and biological/ecological endpoints that impart information pertaining to the integrity of the water resource, and provide the information-base for making water quality-related assessment and management decisions, such as determining the impairment status of the resource.

Environmental indicators have received a lot of attention in recent years, but have also led to some confusion as to their purpose and use. The Intergovernmental Task Force on Monitoring Water Quality (ITFM) defined an environmental indicator as "a measurable feature which singly or in combination provides managerial and scientifically useful evidence of environmental and ecosystem quality or reliable evidence of trends in quality". Inherent in this definition is a hierarchy of indicator types ranging from those emphasizing program-focused activities, such as the *number of discharge permits issued*, to greater reliance on resource-focused measures, such as the assessment of *biological integrity*. Note that the former represents, at best, "managerial evidence of environmental quality" as defined above, whereas the latter provides direct "scientific evidence" of ecosystem quality. The kinds of indicators comprising the hierarchy are:

1) Response Indicators - Measures of integrated or cumulative reactions to exposure and stress, such as biological community indices.

2) Exposure Indicators - Measures of environmental variables that suggest a degree of exposure to stressors, such as water-column pollutant levels or ambient toxicity.

3) Stressor Indicators - Activities that impact the aquatic environment, such as pollutant discharges and changes in land-use and habitat.

4) Administrative Indicators - Regulatory actions by the EPA, the State, and local entities and responses by the regulated community.

Each indicator type in this hierarchy represents a step closer to the direct measure of the integrity of the resource than does the category below it. For example, reliance on administrative and stressor indicators is presumptive - actual instream pollutant concentrations are estimated based on knowledge of the magnitude and quality characteristics of upstream discharges, or conditions are assumed to be improved if a regulatory action is taken. Exposure indicators, such as pollutant concentrations that can be compared to numerical criteria, provide more reliable evidence of instream conditions but still do not account for site-specific factors influencing the biological response to those pollutant concentrations. Therefore, the site-specific application of biological response indicators, such as macroinvertebrate or fish community analyses, allows for greater confidence in the final water resource assessment. By focusing more in the future on indicators that reflect the actual condition of the resource, the 305(b)/303(d) process will be strengthened and attention will be shifted toward solving the most important environmental problems.

In general, monitoring programs focus on measuring exposure, response and, to a lesser degree, stressor indicators. Administrative indicators, which are tracked by counting the number of permits issued or enforcement actions taken, are typically not the subjects of environmental monitoring programs. Massachusetts' water monitoring programs feature a wide variety of water quality, habitat, and public health-related variables that represent the higher tiers in the hierarchy of indicators. For example, emphasis is placed on exposure and response indicators for assessing attainment of water quality standards and/or designated uses. A description of the indicators used by the various monitoring program elements is presented below.

Indicators for Designated Use Assessment

The following table provides a breakdown of core and supplemental indicators chosen for assessing and managing the aquatic life and water contact recreational uses, as defined in the Massachusetts WQS.

INDICATOR TYPE	AQUATIC LIFE*	RECREATION
Core	Macroinvertebrate community Fish community Periphyton/Phytoplankton Macrophyton Habitat quality** Flow Dissolved oxygen pH Temperature Turbidity Suspended solids Lake trophic status	Pathogens (e.g., E. coli) Transparency Algal blooms, chlorophyll Macrophyte density Land-use/% impervious cover
Supplemental	Toxic pollutants (e.g., metals) Toxicity tests (water, sediment) Tissue chemical assays Nutrients Chlorophyll Sediment chemistry Organism condition factor Non-native species Land-use/% impervious cover Fish kills Pollutant loadings	Aesthetics Objectionable scums, sheens, debris, deposits Flow/water level Sediment quality Color/Turbidity pH

* It should be noted that, historically, chemical and physical indicators were emphasized; however, biological monitoring and assessment has assumed a more prominent role in the Massachusetts monitoring program (especially in assessment monitoring).

** Water quantity (discharge)
Geomorphology (slope, bank stability, channel morphology)
Substrate (sediment type, embededness)
Riparian zone (shoreline vegetation, canopy)

Likewise, the table below provides a breakdown of core and supplemental indicators that can be used to assess and manage the human health-related water uses designated in the WQS.

INDICATOR TYPE	FINFISH/SHELLFISH CONSUMPTION	DRINKING WATER
Core	Mercury PCBs Pesticides Shellfish bed closures (non-management)	Primary drinking water standards: e-coli, organic compounds & inorganic constituents, radionuclides (UV254)
Supplemental	Other contaminants of concern Pathogens	Secondary drinking water standards or other health-based advisories: color, iron

Indicators for the identification and location of pollution sources:

Monitoring variables that would be used to identify sources of contaminants (as well as clean-up-related monitoring) would be site- and problem-specific, but would probably include the following:

- Bacteria
- Optical brighteners/fluorescent whitening agents
- Temperature
- pH
- Nutrients
- Other water-column contaminants
- Sediment contaminants (metals, organics)
- Suspended sediment plumes
- Turbidity plumes
- Conductivity plumes
- Habitat alteration such as scouring or high degrees of substrate embeddedness
- Other appropriate, site/incident-specific, information such as fish kills, color violations, excess/nuisance algae, etc.

Indicators for the determination of loadings and trends at fixed sites:

Variables of interest in a fixed-station monitoring program designed to detect trends in loadings to downstream waters are:

- Flow
- Phosphorus
- Nitrogen
- Suspended solids
- Metals
- Priority organics

V. Monitoring Design

Massachusetts has selected a set of monitoring program elements that utilize a combination of deterministically and probabilistically derived sampling networks best suited to meet the previously described monitoring objectives. These monitoring elements incorporate a number of different design components such as fixed-station networks, intensive and screening-level

targeted monitoring, and randomization. Furthermore, these designs encompass both rotating watershed monitoring cycles as well as non-rotating priority-driven schedules.

The Department will continue to take advantage of emerging technologies, such as aerial photography and Geographical Information Systems (GIS), when formulating deterministic monitoring designs and sampling networks. The EPA guidance encourages states to develop tiered networks that work from broad screening approaches for predicting the likelihood of water resource impairments, to more intensive and focused monitoring efforts for confirming problems and developing solutions. For example, headwater streams – which constitute the highest number of stream miles in Massachusetts – could be screened in advance by reviewing GIS data layers for land-use patterns or other landscape indicators in order to identify those streams that are most likely to exhibit altered habitat or pollutant loads. Researchers have demonstrated that watersheds characterized by greater than 10% impervious surface often exhibit some deleterious impact to water quality and stream biota, and that watersheds with greater than 25% impervious cover typically exhibit impairment to designated uses. Similarly, bacterial contamination is more likely to be encountered in watersheds exhibiting less than 75% forested area. These examples illustrate the kind of screening techniques that may be applied to watersheds as part of the monitoring design process in order to focus limited monitoring resources where they have the greatest potential to document water resource impairments in need of correction.

The Department can also explore ways to utilize various permitting programs to identify sampling locations. For instance, It is possible that existing Drinking Water program-related "sites" such as public drinking water wells, reservoirs and river sources, can be used to identify sampling locations to supplement existing monitoring stations. There are 1,684 public water systems in the State, with over 3,200 sources of drinking water that can be considered for sampling. Likewise, the NPDES-permitted facilities have a potential to serve as sampling locations.

Finally, the Department will continue to identify appropriate roles and responsibilities for citizen monitoring programs throughout its system of monitoring networks. While the capabilities of volunteer organizations vary widely, many have the capacity to provide reliable data on basic water quality variables, such as dissolved oxygen, temperature, pH, and Secchi disc measurements. With proper training and technical assistance some citizen monitoring programs can sample for bacteria and nutrient analyses and perform biological (e.g., macroinvertebrates, fish) community analyses and habitat assessments. Furthermore, volunteer groups could be very useful in assisting with the selection of the Department sampling sites for a number of the existing and proposed monitoring programs presented below. Properly trained volunteers could also conduct monitoring/sampling efforts to assist with identifying pollution sources (including wet-weather events). Observations made along stream shorelines could identify discharge pipes, indications of past impacts of storm water runoff (e.g., scouring, sediment deposits, etc), and indications of obvious sources of contaminants, such as agricultural activities, failed septic systems, dry-weather sewage flows, and construction sites with improper sedimentation controls.

<u>Deterministic Sampling Networks</u>

Five-year Rotating Watershed Monitoring for Use Assessments (Objective 1)

(Existing)

In 1993, the twenty-seven major watersheds and coastal drainage areas in Massachusetts were placed on a rotating five-year schedule for monitoring, assessment, TMDL development, surface water permitting, and non-point source pollution control. The rotating watershed cycle

allows for the synchronization of these water quality planning and management activities within each watershed. During Year 1 of the rotating basin schedule all pertinent data and information relative to water resource management are gathered and reviewed to identify data gaps and the need for additional information. Input from outside agencies and the general public is actively solicited in order to gain further insight with respect to water quality goals and use-objectives. This process culminates in the development of a plan for obtaining this information during Year 2. A Quality Assurance Project Plan (QAPP) is formulated for all environmental monitoring activities to be performed. The scope of the monitoring effort varies depending upon the resources available and the prevailing water quality issues within each watershed.

Historically, river and stream surveys were typically performed during low-flow, dry-weather conditions, which generally represented the worst-case scenario with respect to the assessment of impacts on receiving water quality from point discharges. Later, increased attention was given to the identification and control of nonpoint pollution, so survey methods changed to reflect this shift in emphasis. For example, wet-weather sampling may provide the most reliable information pertaining to nonpoint pollutant loadings from stormwater runoff and, when compared with dry-weather survey data, may further distinguish the effects of point and nonpoint pollution sources.

Specific details pertaining to the monitoring efforts that support individual watershed assessments can be found in the Department's watershed assessment reports. However, water quality surveys generally consist of five sampling events interspersed throughout the water recreation season for conventional water quality analyses such as pH, dissolved oxygen, suspended and total dissolved solids, nutrients, and fecal coliform bacteria. River surveys are sometimes supplemented by wastewater discharge sampling, which serves to document pollutant loading from point sources to the river at the time of the survey and to assess compliance with NPDES discharge permit limits. In addition, stream discharge measurements may be made to supplement data from the United States Geological Survey (USGS) stream gages. Discharge measurements provide data for the calculation of pollutant mass loadings, as well as for assessing the impacts on stream biota of low-flow conditions resulting from drought and/or water withdrawals. At times, additional site-specific data are collected for the development of water quality models. These data may include sediment oxygen demand, nutrient flux, and metal toxicity determinations.

Improved knowledge of river flow and water quality conditions upstream of the public drinking water intakes on the Merrimack, Ipswich, Saugus, Shawsheen and Concord Rivers would help with emergency planning and preparedness and also assist with in-stream water quantity issues at those sources and at reservoir and ground water sources in those watersheds.

Massachusetts has placed increased emphasis in recent years on response indicators through the adoption for use of several biomonitoring techniques. Department biologists currently perform habitat assessments and conduct biological community (i.e., macroinvertebrate, fish and periphyton) assessments to determine aquatic life use-support status and to supplement other water quality monitoring and management programs.

Rapid bioassessment protocols (RBPs), based on those developed by the EPA, are used to monitor the health of benthic macroinvertebrate communities in wadeable streams. These methods were developed to minimize laboratory time requirements for taxonomic identification and enumeration of benthos. Kick-net samples are collected at sites for upstream/downstream comparisons, for comparisons against a regional or surrogate reference, or for long-term trend monitoring. Two different levels of analysis are employed, RBP II or RBP III, depending on the objectives to be served. Based on scoring of several metrics, three categories of impairment are discerned by the RBP II (nonimpaired, moderately impaired, and severely impaired), while the RBP III distinguishes between four (nonimpaired, slightly impaired, moderately impaired,

severely impaired). Benthic macroinvertebrate RBPs are conducted at up to 50 sampling sites per year.

The analysis of the structure and function of the finfish community as a measure of biological integrity is also a component of the water quality monitoring program. Fish bioassessment data quality and comparability are assured through the use of qualified fisheries professionals and the application of consistent methods. The Department utilizes a standardized method based on the EPA Rapid Bioassessment Protocol V (RBP V) to improve data comparability among wadeable sampling sites throughout the state. The fish collection procedures employ a multi-habitat approach that allows for sampling of habitats in relative proportion to their local availability. Electrofishing has generally proven to be the most comprehensive and effective *single* method for collecting stream fishes, and is, therefore, the preferred method for obtaining a representative sample of the fish community at each sampling site. Fish (except young-of-the-year) collected within the study reach are identified to species (or subspecies), counted, and examined for external anomalies (i.e., deformities, eroded fins, lesions, and tumors). Aquatic life use-support status is derived from knowledge of the environmental requirements (i.e., water temperature and clarity, dissolved oxygen content, etc.) and relative tolerance to water pollution of the fish species collected.

Algae represent a third community that is typically assessed as part of the biomonitoring efforts. The analysis of the attached algae or periphyton community in shallow streams or the phytoplankton in deeper rivers and lakes employs an indicator species approach whereby inferences on water quality conditions are drawn from an understanding of the environmental preferences and tolerances of the species present. Algal indicators of the presence of elevated metals concentrations, nutrient enrichment, or other pollutants are noted. Because the algal community typically exhibits dramatic temporal shifts in species composition throughout a single growing season, results from a single sampling event are generally not indicative of historical conditions. For this reason the information gained from the algal community assessment is more useful as a supplement to the assessments of other communities that serve to integrate conditions over a longer time period. In some instances, where information pertaining to primary production is required, algal biomass analysis or chlorophyll determinations may be performed. Results of these analyses are used to evaluate the trophic status of lakes, ponds, and impoundments. Similar information from riverine and coastal waters is used to identify those waterbodies subjected to excessive nutrient enrichment. Results at public drinking water reservoirs can indicate whether land uses need to be addressed as sources of nutrients and can help water suppliers adjust treatment processes if necessary.

Continuous, Fixed-site Monitoring for Contaminant Loadings (Objectives 1, 2)

(Proposed)

A monitoring program is needed to determine loads of contaminants carried by major rivers in Massachusetts at strategic locations. This information is needed at the mouths of major rivers to quantify loads delivered to coastal waters, such as Boston Harbor, and major inland waterways, such as the Connecticut River. Information is also needed at State boundaries to determine contaminant loads entering and leaving Massachusetts. The sampling approach suited to the loads monitoring objective is fixed-station monitoring, where the same sites are sampled repeatedly over time and over a range of hydrologic conditions. Repeated sampling over time also generates data that may be suitable for determining trends in water-quality conditions and, over the longer term, for determining trends in contaminant loads. The USGS (2001) has recommended the following fixed station monitoring approach.

Sampling sites

Approximately twenty sampling sites are proposed for the fixed-site network. They are distributed in the following manner: near the mouths of the Merrimack, Aberjona, Charles, Ipswich, Neponset, and Taunton rivers, which collectively drain to Boston Harbor, the Gulf of Maine, and Narragansett Bay; at the mouths of the Millers, Deerfield, Chicopee, and Westfield rivers, which discharge to the Connecticut River; at the mouths of the Concord and Nashua rivers, which discharge to the Merrimack River, and at locations on the Quinebaug, French, Blackstone, West Branch Farmington, Housatonic, and Connecticut Rivers near where they enter and(or) leave the State. Because continuous streamflow records are needed for the accurate calculation of mass discharge (i.e., loads), most of the sites are proposed at or near existing USGS gaging stations. The need for streamflow data limits potential sampling locations on rivers that drain to the coast to sites that are upstream from tidal influences and areas of sluggish flow where streamflow cannot be gaged accurately. In most cases, such as on the Charles River and Aberjona River, existing gages are already located as far downstream as possible for reliable stream gaging. It may be possible to gage streamflow on the Taunton River further downstream than the existing gage; thus, an alternative is proposed that would be downstream from the Taunton urban area. Similarly, a new gage site is proposed on the Merrimack River, near the Haverhill/Methuen line, so that contaminant loads for the Merrimack River would include runoff from as many urban areas and major tributaries as possible. Two other sites are proposed for fixed-station monitoring that currently are not gaged—the Connecticut River at Northfield, near the State boundary with Vermont and New Hampshire, and the Blackstone River at Uxbridge.

The exact location of each sampling site could be changed to accommodate specific water-quality information needs. For example, the proposed site on the Chicopee River at Indian Orchard would exclude pollutant loads from urban runoff, combined sewer overflows, and other sources associated with the City of Chicopee urban area, which is downstream of the proposed site. Similarly, loads to the Connecticut River from the Deerfield River, measured at the existing gage, would exclude the effects of sewage treatment facilities discharging to the Green River, which joins the Deerfield River downstream of the gage. These sites could be moved to capture the effects of the downstream contaminant sources. The site on the West Branch Farmington River, which is intended to represent loads from a relatively undeveloped watershed with no point sources, also could be moved farther downstream toward the Connecticut State border if desired.

Sampling at the proposed sites would provide information to determine contaminant loads from 67 percent of the total land area of Massachusetts. Unsampled areas in the proposed network design are primarily in Eastern Massachusetts. Many of the major basins in Eastern Massachusetts contain many, relatively small streams that discharge directly to the coast, and hydrology on Cape Cod and the Islands is dominated by ground-water flow. It would not be possible to conduct loads monitoring in these areas, given realistic resource limitations. However, special studies that include land-use-based modeling could be used to determine contaminant loadings and water quality.

Fixed Station sampling sites will be added to the network to address information needs that are regional or watershed-based, rather than statewide, in scale. For example, a site in the upper Charles River Basin (near Medway) would be useful to track the trends in constituent concentrations due to the increased development in the upper portions of that basin. A similar argument could be made for the Assabet River (near Maynard), as this river basin is also affected by increased development along the Interstate 495 corridor. Other sites include the Weweantic and North Rivers, which are both coastal streams. The Weweantic River is influenced by cranberry cultivation within its basin, and the Weweantic and North Rivers both are affected by increased development. The location of additional watershed-based sites will

be dictated by the assessment monitoring program conducted on a five-year rotating schedule, discussed elsewhere in this report.

Water quality variables

Data resulting from the fixed station monitoring program will provide information for determining loadings to downstream waters, and over time, trends in those loadings. Loadings to downstream waters will be determined for phosphorus, nitrogen, and suspended solids. Sampling for other variables, such as selected metals or organic compounds, could be added based on specific information needs at some sites or previous knowledge of impairments, for example, at sites near the Massachusetts–Connecticut border. Furthermore, variables such as dissolved oxygen and pathogens that would support use assessment could be added to the network; however, this would be of limited value because of the sparse spatial coverage of the sampling sites.

Sampling frequency

The sampling frequency is determined by the need to adequately characterize the range of hydrologic and seasonal conditions for loads calculations. Thus, monthly sampling frequency is needed, but samples need not be at strictly regular intervals. Additional samples will likely be needed during high- and low-flow periods to fully cover the range of hydrologic conditions and characterize wet-weather conditions. This is particularly important for suspended sediment and sediment-associated contaminants such as phosphorus and metals, because sediment concentrations are variable and depend on changing flow conditions. Fifteen samples per year at each site are initially proposed; this sampling frequency is consistent with the recently redesigned USGS NASQAN sampling program for contaminant loads on freely flowing large rivers. The sampling frequency will be assessed and, if necessary, revised after several years of data collection and analysis.

Targeted Monitoring Strategies (Objectives 3-5)

A broad array of monitoring program elements focus on or "target" particular sites, areas or issues that require directed, and often comprehensive, sampling and analytical coverage. Targeted monitoring may be project-specific or issue-specific, but is often more site-specific and is sometimes of shorter duration than is monitoring to assess uses or detect trends. Targeted designs may be used to identify causes and sources of impairments for reporting pursuant to sections 305(b) and 303(d) of the CWA, and to develop and implement control strategies such as TMDLs, NPDES permits, or Best Management Practices (BMP). Furthermore, targeted monitoring may provide data and information to definine new and emerging issues or to support the formulation of water quality standards and policies. For both ground and surface drinking water sources, targeted monitoring could provide information on potential contamination from explosives, pharmaceuticals and emerging unregulated contaminants for the protection of public health. In any case, this category encompasses monitoring designs that are typically not implemented as fixed-site networks or in accordance with the rotating watershed schedule, although there are often logistical advantages to following this schedule for some targeted monitoring programs. These are noted in the discussion of the individual designs below.

Targeted Monitoring to Assess Bioaccumulation

(Existing)

The Department collects some aquatic organisms to be assayed for the presence of toxic contaminants that may be sequestered in their tissues. The goal of this monitoring element is primarily to provide data for the assessment of the risk to human consumers associated with the

consumption of freshwater finfish. In the past fish collection efforts were generally restricted to waterbodies where wastewater discharge data or previous water quality studies indicated potential toxic contamination problems. More recently concerns about mercury contamination from both local and far-field sources have led to a broader survey of waterbodies throughout Massachusetts. In both cases, the analyses have been restricted to edible fish fillets. This "Toxics-in-Fish" monitoring program is a cooperative effort of the Department of Environmental Protection, the Department of Fish and Game (DFG), and the Department of Public Health (DPH). Uniform protocols, designed to assure accuracy and prevent cross-contamination of samples, are followed for fish collection, processing and shipping. Fish are typically obtained with electrofishing gear or gill nets. Lengths and weights are measured and fish are visually examined for tumors, lesions, or other indications of disease. Data are provided to the DPH, which is the agency responsible for performing the risk assessments and issuing public health advisories.

Tissue bioassays to trace the fate and transport of toxic contaminants in the aquatic environment are performed on a limited basis, primarily to support waste site clean-up activities. To date, caddisfly and crayfish bioassays have been used to identify possible sources of polychlorinated biphenyls (PCB) in selected watersheds.

Targeted Monitoring of Massachusetts Lakes

(Existing)

The Department's Lake Water Quality Monitoring Program was formally initiated in 1974 and was significantly expanded in its scope during the 1980s. Historically, limnological sampling was conducted to: a) determine baseline lake conditions for assessment purposes, b) monitor post-implementation project effects, and c) respond to public concerns about lake problems. Over the past several years, however, lake monitoring has been considerably reduced. Although the current amount of lake monitoring is less than it was at the peak of the program, the monitoring that is performed is targeted in the highest priority areas. Lake sampling by the Department presently consists of biological surveys of the macrophyton (i.e., aquatic vascular plants) community, "in-situ" measurements using metered probes, and limited water quality sampling to provide data for the calculation of TMDLs or the derivation of nutrient criteria. Lake surveys are generally conducted on multiple days for TMDL development and consist of bathymetric mapping; physical, chemical and biological sampling of the open water areas, tributary stream(s), and outlet; and a quantitative and qualitative mapping of the aquatic macrophyton community. The lake is sampled during the summer months when productivity is high.

Some limited use assessments may be accomplished through the lake monitoring described above depending upon the scope of the individual lake surveys. Cover estimates and species distribution of macrophytes, and measurements of water column transparency support a limited assessment of the recreational uses. Finally, macrophyte surveys are used to document the spread of several non-native and potentially nuisance aquatic plant species that are known to be present in Massachusetts.

(Proposed)

There exists a need to establish a more comprehensive monitoring program for assessing the condition of Massachusetts' lakes and ponds. This program could adopt a deterministic monitoring design and follow the five-year rotating watershed monitoring and assessment cycle, or it could be based on a probabilistic sampling design that would allow for statewide inferences to be drawn on the status of all lakes from an assessment of a random sample. In either case, lake monitoring should be expanded to provide adequate spatial, temporal and analytical

coverage to assess all designated uses.

A proposed “raw water” sampling program, to be conducted at drinking water supplies located in surface waters will provide additional information for public health and for assessing conditions and water quality trends of these waters. Raw water quality monitoring at public drinking water reservoirs and their tributaries, to look at trends in organics, inorganics and microbial contamination, would help public water suppliers develop source protection strategies and provide for more effective water treatment. Public water suppliers may be able to assist with this sampling effort.

Sampling for E. coli at small systems with reservoirs would help these systems meet the Long-term II Enhanced Surface Water Treatment Rule. For small reservoir systems with slow sand filtration, sampling for color, UV254 and TOC would help them meet the Disinfection By-products Rule.

Targeted Monitoring to Support TMDL Development and Clean-up Strategies

(Proposed)

Targeted monitoring data are needed to support permitting decisions and the development of simulation models to be used for calculating Total Maximum Daily Loads (TMDLs) for impaired water bodies. The TMDL process establishes the maximum allowable loading of pollutants that a water body can receive and still meet the standards established for protecting public health and maintaining the designated beneficial uses of those waters. The TMDL process provides a mechanism for reducing pollution from both point and nonpoint sources and restoring and maintaining the quality of water resources.

The majority of the monitoring to support TMDL development undertaken by the Department to date has been limited to that performed in lakes as described under “Targeted Monitoring of Massachusetts’ Lakes” above. However, the Department must develop TMDLs for over 1,500 river, lake, or estuary segments in the next ten to fifteen years. Computer models and other forecasting tools will be utilized to evaluate and make recommendations for pollutant allocation alternatives that are feasible and cost-effective. Monitoring data will be needed to calibrate and verify these models before they can be used to predict the impact of various loading scenarios. Furthermore, monitoring will be needed to determine existing loads, locate sources of pollution and evaluate the effectiveness of pollution control measures.

Targeted Monitoring to Locate Sources of Bacterial Contamination

(Pilot project)

A recent review of existing data and 303(d) listings revealed that bacterial contamination is one of the leading causes of impairment in Massachusetts waters. As a result of this finding a pilot program has been established to formulate and implement protocols for locating sources of bacteria. While targeted monitoring is an integral component of the source locating process, the protocols also make recommendations for using the monitoring results to implement follow-up corrective actions. While the methodologies developed thus far are aimed at bacteria monitoring, the conceptual framework will eventually be modified to identify sources of other contaminants as well. A detailed Quality Assurance Project Plan (QAPP) has been prepared that outlines the details of each of the following steps in the process:

1) Identify and prioritize contaminated subwatershed(s) for locating sources;
2) Characterize the priority subwatershed(s);
3) Design and carry out screening-level sampling; and

4) Evaluate screening level data and design and perform source location monitoring.

Highlights of this targeted monitoring design include the use of GIS land-use coverages, other overlays, and orthophotos to identify potential sources, and the use of both dry weather and wet weather sampling to determine the contribution of stormwater runoff to the bacterial content of surface waters. The monitoring design employs an iterative sampling process that involves the adjustment of sampling site locations in response to a timely review of previous results in an effort to narrow down the exact location of the bacteria sources.

A key element of this project is the capacity to analyze a large number of samples while maintaining rapid turn-around time between the collection of those samples and the availability of the analytical results. This is essential for the determination of how to proceed with subsequent sampling. To this end, the Department purchased and installed the IDEXX, Inc. Colilert® and Enterolert® testing systems at its laboratory facility in Worcester. Use of this EPA-approved technology will lessen the burden placed on the Department's Wall Experiment Station for bacterial analyses and decrease sample delivery time.

The sampling strategy will include the bracketing of suspected point sources (e.g., pipes, ditches, culverts) and non-point sources (e.g., specific land-use types, small tributaries, neighborhoods). Sampling stations will also include baseline "pour point" stations established during screening level sampling to document and track reference conditions.

Sampling results, associated subwatershed information, and local input will be used to identify sources of bacteria contamination to the extent of the Department jurisdictional authority, at a minimum. Appropriate authorities will be notified of the suspected source(s) and recommendations for further source tracking work (e.g., for likely illicit discharges to storm sewer), clean-up, or enforcement action will be made.

Drinking Water Program monitoring of surface and groundwater supplies (Objectives 6 – 9)

(proposed)

Permitted Drinking Water suppliers (ground water and surface water sources) currently provide data on the finish (treated) waters. The Department proposes to establish a monitoring program to assess the quality of raw water (described in Appendix 3). These monitoring programs, in addition to providing the obvious public health – related information, will provide additional data on selected surface waters serving as drinking water sources, and will fill a gap in our knowledge of the quality of groundwater.

<u>Probabilistic Sampling Networks</u>

(Proposed)

The EPA guidelines for the development of state monitoring programs call for the development of sampling networks that will provide comprehensive assessments of all waters and water body types (e.g., wadeable streams, large rivers, lakes, wetlands, etc.) over time. To provide complete coverage, both spatially and temporally, states are encouraged to adopt networks of randomly selected sampling sites that will allow for statistically unbiased assessments that can be applied at larger scales. Because statistically valid inferences can be drawn for an entire population of water bodies by monitoring a set of sites randomly selected from that population, a probabilistic design can achieve the goal of reporting in Section 305(b) reports the status of all waters without actually having to monitor them all. The actual number of sites chosen for monitoring will affect the overall confidence that can be placed in extrapolating up to a scale

beyond the individual sites or waters sampled. These probabilistic monitoring designs are in contrast with deterministic designs that utilize non-random site selection based on previous knowledge of conditions at the sites.

EPA's Environmental Monitoring and Assessment Program (EMAP) has been employing probabilistic sampling designs for several years to assess the condition of aquatic resources over large areas. This program has demonstrated the utility of these designs for inferring conditions on a watershed, state, or even regional scale, and several states have adopted probabilistic monitoring networks for use in reporting on the status of their water resources in 305(b) reports. However, it is important to acknowledge the limitations of probabilistic monitoring designs, and their use should augment, rather than replace, deterministically derived sampling networks in state monitoring programs. While there is certainly value in knowing what percentage of a state's stream miles are meeting standards, it is equally important, if not more so, to know exactly which waters are impaired in order to implement pollution control measures. Other than the specific sites found to be impaired within the random sample of monitored water bodies, probabilistic sampling designs are not well suited to making local inferences as to which unmonitored waters are actually impaired. Therefore, it is also important for states to perform deterministic assessments aimed at identifying impaired waters, determining the causes and sources of those impairments, and planning and performing clean-up activities.

Massachusetts acknowledges the important role probabilistic monitoring designs can play in a comprehensive state water quality monitoring program. However, personnel and other resource limitations have precluded the development and initiation of probabilistically designed monitoring networks in the past. Even today, with state officials faced with an overwhelming number of 303(d)-listed waters, priority is given to monitoring strategies that will support modeling efforts, the derivation of TMDLs, and the implementation of pollution control programs. Nonetheless, a probabilistic monitoring design is proposed as one element of this strategic monitoring plan for Massachusetts.

Probabilistic monitoring is proposed for wadeable streams, lakes and ponds. In general wadeable streams comprise first- through third-order and some fourth-order streams. Many of the smaller headwater streams and smaller tributaries to main stem rivers have not been monitored in the past, and a probabilistic design will provide an estimate of the condition of those water body types. At a minimum, the probabilistic designs will be aimed at evaluating the aquatic life use and recreational uses of the waters in question, with emphasis placed on the use of biomonitoring techniques to assess the former. There are several procedures that can be utilized to select sampling sites; however, a preferred option is not presented at this time. Rather, these procedures will be evaluated for use nearer to the time the probabilistic network is to be established. Sampling designs, however, will entail stratification of the water body types, such as size, stream order, watershed size, percent impervious surface, or by selected land use data; followed by random selection of stations within each "strata".

The Department in the past has not conducted ground water monitoring. Fortunately, existing drinking water wells across the state provide potential ground water sampling opportunities. Currently, monitoring at these wells is conducted after treatment. Raw water testing at public drinking water wells, on the other hand, would provide information on the quality of groundwater that could be used by public water suppliers to proactively evaluate treatment requirements and to develop source protection strategies. In addition, an assessment of the overall quality of ground water throughout Massachusetts could be gained using a probability-based sampling of those drinking water wells that are not influenced by surface water.

The USGS recommendations for a statewide water quality network for Massachusetts suggested that collaboration with the EPA regional EMAP (i.e., R-EMAP) programs would be an efficient and effective way to select sites for the probabilistic monitoring program. To this end,

the Department has followed the development and completion of the New England Wadeable Streams (NEWS) monitoring program in Region 1 despite being unable to devote resources to more active participation in the project. Likewise, the Department will monitor the progress of the Region 1 probabilistic sampling planned for lakes and ponds. Massachusetts looks forward to applying these techniques when monitoring resources become available.

VI. Quality Assurance

A system for assuring the reliability of scientific data and related information is an essential component of any environmental monitoring program and the Department is committed to ensuring that the monitoring data used to support the various water quality management activities specified in the CWA are of known and documented quality. This is achieved through the implementation of a Quality Management Plan for Federally Funded Programs that is revised every five years and submitted to the EPA for review and approval. This plan describes the policies and procedures used by the Department to make certain that all data and information collected in support of programs to assess, protect and improve the environment are sufficient for their intended purpose.

The Quality Management Plan describes each element of the total quality system employed by the Department. Standard Operating Procedure (SOP) documents are prepared for all field and laboratory operations and are revised as needed to reflect changes in methodologies. All field and laboratory personnel receive periodic training in the execution of the SOPs. Individual Quality Assurance Project Plans (QAPPs) are prepared for each monitoring project. These may be prepared for a specific monitoring program element, such as benthic macroinvertebrate biomonitoring or fish toxics monitoring, or to cover all monitoring elements to be performed in a certain watershed and year (e.g., “2001 Monitoring Plan for the Taunton Watershed”). In either case, these plans clearly document in detail all aspects of the proposed monitoring program, including the goals and objectives of the monitoring to be carried out, the sampling design and logistics, data quality objectives (DQO) for precision and accuracy, equipment, personnel and training needs, quality assurance measures, and data management and reporting elements. The QAPPs are submitted to EPA for review and approval before the project work is initiated.

The Department’s Division of Watershed Management (DWM) employs one full-time Quality Control Analyst who oversees the development of SOPs and QAPPs, coordinates staff training exercises, performs periodic field audits, and assists with data validation procedures. This staff member also serves as the liaison between the Department and EPA quality assurance personnel.

VII. Data Management

The DWM’s *SOP for Data Validation and Usability* sets forth the steps currently taken to validate and verify environmental monitoring data. It provides guidance for accepting, qualifying, or rejecting data from a variety of sources. The DWM’s data validation process includes the review of both field-recorded data and laboratory analytical data for conformance with the data quality objectives established in project-specific or programmatic QAPPs. These measures are implemented along with separate quality assurance and quality control activities performed at WES or any other analytical laboratory.

Results of the DWM data review process are documented in annual data validation reports that present the final recommendations with respect to the acceptability and suitability of the data for their intended purpose. Following this determination, data are entered with applicable qualifiers into electronic databases for storage and dissemination. The DWM currently maintains approximately a dozen electronic databases at various stages of development and use.

Several of these are Access database structures designed to store environmental data generated by internal monitoring program elements, such as surface water quality, lake macrophytes, and benthic macroinvertebrates. Others are assessment databases or water body inventories that parse Massachusetts' rivers, lakes and coastal water bodies into segments of manageable size for assessment and reporting convenience. To date, the DWM has stored the results of its watershed assessments segment-by-segment in a database called the Water Body System (WBS). However, a transition to the use of a new Assessment Database (ADB) developed by the EPA is anticipated for the 2006 Integrated List of Waters.

Information contained in the DWM databases is essential to the Department in order to meet key obligations to the EPA under the Clean Water Act as defined in the annual Performance Partnership Agreement (PPA). Such deliverables as watershed assessment reports, integrated 305(b) reports and 303(d) lists, water quality maps, and TMDLs are generated from the monitoring, assessment and modeling activities performed by the DWM. These activities, in turn, are supported by the less visible, but critically important functions relating to data management, including QA/QC, database development and maintenance, and the linking to Geographical Information Systems (GIS) and, ultimately, to external data storage and retrieval systems such as STORET. The DWM continually receives requests to make its information and data available to the Department's regional offices, the EPA, and the general public. This is a key goal of ongoing database development and GIS program activities.

VIII. Data Analysis and Assessment

Sources of Existing and Available Data and Information

Reliable scientific data and technical information are essential for making water use assessments. The Department draws from a diverse information base in order to do so. Over the past 35 years the DWM (and its predecessor agency) has collected water quality and biological information at over 3,000 locations in the state and published hundreds of technical reports on this information. A listing of these reports, by watershed, is published annually as "Publications of the Division of Watershed Management, 1963 – (current year)" and is available through the DWM Office in Worcester, Massachusetts.

It is EPA policy (EPA Order 5360.1 CHG 1) that any organization performing work for or on behalf of the EPA must establish a quality system to support the development, review, approval, implementation, and assessment of data collection operations. To this end, the Department describes its Quality System in an EPA-approved Quality Management Plan to ensure that environmental data are of known and documented quality and are suitable for their intended use. In addition, a SOP document outlines the procedures that are used for the validation of field and laboratory data. The Department will accept and review data and information pertaining to the quality of Massachusetts waters from any and all sources. However, for external sources of information intended to be used for regulatory purposes the Department requires the following: 1) an appropriate Quality Assurance Project Plan including a laboratory Quality Assurance/Quality Control (QA/QC) plan, 2) use of a state certified lab (certified for the applicable analyses), 3) data management QA/QC are described, and 4) the information be documented in a citable report that includes QA/QC analyses.

Specific sources of information used for assessments can be found in individual watershed reports. They include monitoring data reports from state and federal agencies and nongovernmental organizations (NGO), as well as reports on projects resulting from state or local grants or federally funded through sections 314, 319, 104, or 604(b) of the CWA. Section 314 of the CWA provided for cooperative agreements between federal, state and local entities to restore publicly owned freshwater lakes and ponds and protect them against degradation. During the late 1970s through the early 1990s diagnostic and feasibility (D&F)

studies were completed for several lakes and ponds throughout Massachusetts and these were used in earlier 305(b) assessments and 303(d) listing decisions. Information from these studies continues to carry over into new assessment and listing cycles unless new monitoring information results in a change in their assessment and listing status. Likewise, information contained in the nonpoint source assessment report prepared in 1989 in accordance with the requirements of section 319 is also reflected in 305(b) and 303(d) reporting elements unless more recent information has resulted in a modification of the original assessment.

The following generic list provides sources that are typically consulted when making watershed assessments. More detail pertaining to the monitoring programs of some of the agencies listed below can be found in Appendix 1. Note, however, that this list is not complete and individual watershed assessment reports should be consulted for specific lists of references.

State Agencies

Department of Environmental Protection - Drinking Water Program
Department of Environmental Protection - Wetlands and Waterways Program
Department of Environmental Protection - Watershed Permitting Program
Massachusetts Office of Coastal Zone Management (CZM)
Massachusetts Department of Conservation and Recreation (MDCR)
Massachusetts Division of Marine Fisheries
Massachusetts Division of Fish and Wildlife
Massachusetts Department of Public Health (DPH)
Massachusetts Water Resources Authority (MWRA)
MassGIS data layers pertaining to land use, percent impervious cover, pollution sources, etc.

Federal Agencies

U.S. Geological Survey
U.S. Environmental Protection Agency
National Estuaries Program
U.S. Fish and Wildlife Service
U.S. Army Corps of Engineers
National Oceanographic and Atmospheric Administration

Private Consulting Firms

Municipal Facilities Plans
Massachusetts Clean Lakes Program “Chapter 628” projects (70 lakes)
Service Contract for Toxicity Testing

Other Sources

Woods Hole Oceanographic Institute
Water Resources Research Center
Massachusetts Institute for Social and Economic Research
Boston Harbor Symposium Abstracts
Colleges, Universities and associated academic institutions
Watershed and lake associations (citizen monitoring programs)
Municipal Conservation Commissions (nonpoint source assessment)
Municipal and Industrial NPDES Permit Monitoring Requirements
Public drinking water systems

Assessment Process Overview

The CWA Section 305(b) water quality reporting process, embodied in the Department's watershed assessment reports and the Integrated List, is an essential aspect of the Nation's water pollution control effort. It is the principal means by which EPA, Congress, and the public evaluate existing water quality, assess progress made in maintaining and restoring water quality, and determine the extent of remaining problems. In so doing, the States report on waterbodies within the context of meeting their designated uses. These uses include: *Aquatic Life, Fish Consumption, Drinking Water, Primary Contact Recreation, Secondary Contact Recreation, Shellfish Harvesting* and *Aesthetics*. Two subclasses of Aquatic Life that are also designated in the standards are Cold Water Fishery (capable of sustaining a year-round population of cold water aquatic life, such as trout), and Warm Water Fishery (waters that are not capable of sustaining a year-round population of cold water aquatic life).

The Water Quality Standards prescribe minimum water quality criteria to sustain the designated uses. Furthermore, these standards describe the hydrological conditions at which water quality criteria must be applied. In rivers, the lowest flow conditions at and above which aquatic life criteria must be applied are the lowest mean flow for seven consecutive days to be expected once in ten years (7Q10). In artificially regulated waters, the lowest flow conditions at which aquatic life criteria must be applied are the flow equal or exceeded 99% of the time on a yearly basis or another equivalent flow. In coastal and marine waters and for lakes the Department on a case-by-case basis shall determine the most severe hydrological condition to which the aquatic life criteria must be applied.

The determination of whether or not a waterbody supports each of its designated uses is a function of the type(s), quality and quantity of available current information. Although data/information older than five years are usually considered "historical" and used for descriptive purposes, they can be utilized in the use attainment determination provided they are known to reflect the current conditions. While the water quality standards prescribe minimum water quality criteria to sustain the designated uses, numerical criteria are not available for every indicator of pollution. Best available guidance in the literature may be applied in lieu of actual numerical criteria. Excursions from criteria due solely to "naturally occurring" conditions do not constitute violations of the WQS.

Each designated use within a given segment is individually assessed as ***support*** or ***impaired***. When too little current data/information exists or no reliable data are available, the use is ***not assessed***. It is important to note that not all waters are assessed. Many small and/or unnamed ponds, rivers, and estuaries are currently ***unassessed***; the status of their designated uses has never been reported to the EPA in Massachusetts 305(b) reports or in the Integrated List. Details pertaining to the assessment of each use are presented below.

Individual Use Assessments

The Massachusetts Surface Water Quality Standards designate the most sensitive uses for which the surface waters of the Commonwealth shall be enhanced, maintained and protected. The guidance used to assess the *Aquatic Life, Fish Consumption, Drinking Water, Shellfish Harvesting, Primary Contact Recreation, Secondary Contact Recreation* and *Aesthetics Uses* is presented below. Literature cited in the summary boxes for each use can be found under "References for Individual Use Assessments" in Section XII.

Aquatic Life Use

Waters designated for this use must provide suitable habitat for sustaining a native, naturally

diverse community of aquatic flora and fauna. Two subclasses of aquatic life are also designated in the standards for freshwater bodies: *Cold Water Fishery* - capable of sustaining a year-round population of cold water aquatic life, such as trout; *Warm Water Fishery* - waters that are not capable of sustaining a year-round population of cold water aquatic life.

Biological (including habitat evaluations), toxicological and chemical data may all be utilized to assess this use. However, the nature, frequency and precision of the Department's data collection techniques dictate that a "weight of evidence" approach be used to complete the assessment with biomonitoring results used as the final arbiter of borderline cases.

The chart on the next page provides an overview of the guidance used to assess the status (support or impaired) of the *aquatic life use*.

AQUATIC LIFE USE

Variable	***Support*** – Data available clearly indicates support or minor modification of the biological community. Excursions from chemical criteria not frequent or prolonged and may be tolerated if the biosurvey results demonstrate support.	***Impaired*** – There are frequent or severe violations of chemical criteria, presence of acute toxicity, or a moderate or severe modification of the biological community.
BIOLOGY		
Rapid Bioassessment Protocol (RBP) III*	Non/Slightly impacted	Moderately or Severely Impacted
Fish Community	Best Professional Judgment (BPJ)	BPJ
Habitat and Flow	BPJ	Dewatered streambed due to artificial regulation or channel alteration, BPJ
Eelgrass Bed Habitat (Howes et al. 2002)	No/minimal loss, BPJ	Moderate/severe loss, BPJ
Macrophytes	BPJ	Exotic species present, BPJ
Plankton/ Periphyton	No/infrequent algal blooms	Frequent and/or prolonged algal blooms
TOXICITY TESTS**		
Water Column/Ambient	≥75% survival either 48 hr or 7-day exposure	<75% survival either 48 hr or 7-day exposure
Sediment	≥75% survival	<75% survival
CHEMISTRY-WATER**		
Dissolved oxygen (DO)/percent saturation (MADEP 1996, EPA 1997)	Infrequent excursion from criteria, BPJ (minimum of three samples representing critical period)	Frequent and/or prolonged excursion from criteria [river and shallow lakes: exceedances >10% of measurements; deep lakes (with hypolimnion): exceedances in the hypolimnetic area >10% of the surface area].
pH (MA DEP 1996, EPA 19 November 1999)	Infrequent excursion from criteria	Criteria exceeded >10% of measurements.
Temperature (MADEP 1996,EPA 1997)	Infrequent excursion from criteria[1]	Criteria exceeded >10% of measurements.
Toxic Pollutants (MADEP 1996, EPA 19 November 1999) Ammonia-N (MADEP 1996, EPA 1999) Chlorine (MADEP 1996, EPA 19 November 1999)	Infrequent excursion from criteria Ammonia is pH and temperature dependent[2] 0.011 mg/L (freshwater) or 0.0075 mg/L (saltwater) total residual chlorine (TRC)[3]	Frequent and/or prolonged excursion from criteria (exceeded >10% of measurements).
CHEMISTRY-SEDIMENT**		
Toxic Pollutants (Persaud et al. 1993)	Concentrations ≤ Low Effect Level (L-EL), BPJ	Concentrations ≥ Severe Effect Level (S-EL)[4], BPJ
CHEMISTRY-TISSUE		
PCB – whole fish (Coles 1998)	≤500 μg/kg wet weight	BPJ
DDT (Environment Canada 04 November 1999)	≤14.0 μg/kg wet weight	BPJ
PCB in aquatic tissue (Environment Canada 04 November 1999)	≤0.79 ng TEQ/kg wet weight	BPJ

*RBP II analysis may be considered for assessment decision on a case-by-case basis, **For identification of impairment, one or more of the following variables may be used to identify possible causes/sources of impairment: NPDES facility compliance with whole effluent toxicity test and other limits, turbidity and suspended solids data, nutrient (nitrogen and phosphorus) data for water column/sediments. [1]Maximum daily mean T in a month (minimum six measurements evenly distributed over 24-hours) less than criterion. [2] Saltwater is temperature dependent only. [3] The minimum quantification level for TRC is 0.05 mg/L. [4]For the purpose of this report, the S-EL for total polychlorinated biphenyl compounds (PCB) in sediment (which varies with Total Organic Carbon (TOC) content) with 1% TOC is 5.3 ppm while a sediment sample with 10% TOC is 53 ppm.

Note: National Academy of Sciences/National Academy of Engineering (NAS/NAE) guideline for maximum organochlorine concentrations (i.e., total PCB) in fish tissue for the protection of fish-eating wildlife is 500μg/kg wet weight (ppb, not lipid-normalized). PCB data (tissue) in this report are presented in μg/kg wet weight (ppb) and are not lipid-normalized to allow for direct comparison to the NAS/NAE guideline.

Fish Consumption Use

Fish Consumption Use

Pollutants shall not result in unacceptable concentrations in edible portions of marketable fish or for the recreational use of fish, other aquatic life or wildlife for human consumption. The assessment of this use is made using the most recent list of Fish Consumption Advisories issued by the Massachusetts Executive Office of Health and Human Services, Department of Public Health (MDPH), Bureau of Environmental Health Assessment. The MDPH list identifies waterbodies where elevated levels of a specified contaminant in edible portions of freshwater species poses a health risk for human consumption. Hence, the Fish Consumption Use is assessed as non-support in these waters. A list of all MDPH site-specific fish consumption advisories currently in force can be found on their website at http://www.state.ma.us/dph/beha/fishlist.htm.

In July 2001, the MDPH issued new consumer advisories on fish consumption and mercury contamination. The MDPH "…is advising pregnant women, women of childbearing age who may become pregnant, nursing mothers and children under 12 years of age to refrain from eating the following marine fish: shark, swordfish, king mackerel, tuna steak and tilefish. In addition, the MDPH is expanding its previously issued statewide fish consumption advisory which cautioned pregnant women to avoid eating fish from all freshwater bodies due to concerns about mercury contamination, to now include women of childbearing age who may become pregnant, nursing mothers and children under 12 years of age."

Additionally, the MDPH "…is recommending that pregnant women, women of childbearing age who may become pregnant, nursing mothers and children under 12 years of age limit their consumption of fish not covered by existing advisories to no more than 12 ounces (or about 2 meals) of cooked or uncooked fish per week. This recommendation includes canned tuna, the consumption of which should be limited to 2 cans per week. Very small children, including toddlers, should eat less. Consumers may wish to choose to eat light tuna rather than white or chunk white tuna, the latter of which may have higher levels of mercury."

Other statewide advisories that the MDPH has previously issued and are still in effect are as follows:

1. Due to concerns about chemical contamination, primarily from polychlorinated biphenyl compounds (PCB) and other contaminants, no individual should consume lobster tomalley from any source. Lobster tomalley is the soft green substance found in the tail and body section of the lobster.

2. Pregnant and breastfeeding women and those who are considering becoming pregnant should not eat bluefish due to concerns about PCB contamination in this species.

The MDPH statewide advisory does not include fish stocked by the state Division of Fisheries and Wildlife or farm-raised fish sold commercially. Because of the statewide advisory, however, no waters can be assessed as support for the *fish consumption use*. Therefore, if no site-specific advisory is in place, the fish consumption use is not assessed. The following is an overview of the guidance used to assess the status (support or impaired) of the *fish consumption use*.

Variable	***Support*** – No restrictions or bans in effect	***Impaired*** – There is a "no consumption" advisory or ban in effect for the general population or a sub-population for one or more fish species or there is a commercial fishing ban in effect
MDPH Fish Consumption Advisory List (MDPH 2002a, MDPH 2001)	Not applicable, precluded by statewide advisory (Hg)	Waterbody on MDPH Fish Consumption Advisory List

Drinking Water Use

The term *Drinking Water Use* denotes those waters used as a source of public drinking water. These waters may be subject to more stringent regulation in accordance with the Massachusetts Drinking Water Regulations (310 CMR 22.00). They are designated for protection as Outstanding Resource Waters in 314 CMR 4.04(3). The Department's Drinking Water Program (DWP) has primacy for implementing the provisions of the federal Safe Drinking Water Act (SDWA). Except for suppliers with surface water sources for which a waiver from filtration has been granted (these systems also monitor surface water quality) all public drinking water supplies are monitored as finished water (tap water). Monitoring includes the major categories of contaminants established in the SDWA: bacteria, volatile and synthetic organic compounds, inorganic compounds and radionuclides. The DWP maintains current drinking supply monitoring data. The status of the supplies is currently reported to the Department and the EPA by the suppliers on an annual basis in the form of a consumer confidence report (http://yosemite.epa.gov/ogwdw/ccr.nsf/Massachusetts). Below is EPA's guidance to assess the status (support or impaired) of the drinking water use.

Variable	***Support*** – No closures or advisories (no contaminants with confirmed exceedances of maximum contaminant levels, conventional treatment is adequate to maintain the supply).	***Impaired*** – Has one or more advisories or more than conventional treatment is required or has a contamination-based closure of the water supply.
Drinking Water Program (DWP) Evaluation	See note below	See note below

Note: While this use is not assessed in individual watershed assessment reports, information on drinking water source protection and finish water quality is available from individual municipal water suppliers.

Section 1453 of the SDWA requires each state to develop a comprehensive Source Water Assessment Program (SWAP) that will result in assessments of every public water system in the state. These assessments are to include the delineation of the areas needed to protect the drinking water source, an inventory of potential contaminant sources, and a determination of the water's susceptibility to contamination. While Massachusetts is currently implementing the provisions of section 1453, actual ambient water quality data have not been obtained and SWAP assessments were not yet available for the watershed assessments supporting the 2004 Integrated List. The Department anticipates using this information in future assessments as it becomes available.

Shellfish Harvesting Use

This use is assessed using information from the Department of Fish and Game's Division of Marine Fisheries (DMF). A designated shellfish growing area is an area of potential shellfish habitat. Growing areas are managed with respect to shellfish harvest for direct human consumption and include at least one or more classification areas. The classification areas are the management units, which range from being approved to prohibited (described below) with respect to shellfish harvest. Shellfish areas under management closures are *not assessed.* Not

enough testing has been done in these areas to determine whether or not they are fit for shellfish harvest, so they are closed for the harvest of shellfish.

Variable	***Support*** – SA Waters—Approved[1] SB Waters— Approved[1], Conditionally Approved[2] or Restricted[3]	***Impaired*** – SA Waters— Conditionally Approved[2], Restricted[3], Conditionally Restricted[4], or Prohibited[5] SB Waters—Conditionally Restricted[4] or Prohibited[5]
DMF Shellfish Project Classification Area Information (DFWELE 2000)	Reported by DMF	Reported by DMF

NOTE: Designated shellfish growing areas may be viewed using the MassGIS datalayer available from MassGIS at http://www.state.ma.us/mgis/dsga.htm. This coverage currently reflects classification areas as of July 1, 2000.

[1] **Approved** - "...open for harvest of shellfish for direct human consumption subject to local rules and regulations..." An approved area is open all the time and closes only due to hurricanes or other major coastwide events.

[2] **Conditionally Approved** - "...subject to intermittent microbiological pollution..." During the time the area is open, it is "...for harvest of shellfish for direct human consumption subject to local rules and regulations…" A conditionally approved area is closed some of the time due to runoff from rainfall or seasonally poor water quality. When open, shellfish harvested are treated as from an approved area.

[3] **Restricted** - area contains a "limited degree of pollution." It is open for "harvest of shellfish with depuration subject to local rules and state regulations" or for the relay of shellfish. A restricted area is used by DMF for the relay of shellfish to a less contaminated area.

[4] **Conditionally Restricted** - "...subject to intermittent microbiological pollution..." During the time area is restricted, it is only open for "the harvest of shellfish with depuration subject to local rules and state regulations." A conditionally restricted area is closed some of the time due to runoff from rainfall or seasonally poor water quality. When open, only soft-shell clams may be harvested by specially licensed diggers (Master/Subordinate Diggers) and transported to the DMF Shellfish Purification Plant for depuration (purification).

[5] **Prohibited -** Closed for harvest of shellfish.

Primary Contact Recreational Use

This use is suitable for any recreational or other water use in which there is prolonged and intimate contact with the water with a significant risk of ingestion of water during the primary contact recreation season (1 April to 15 October). These include, but are not limited to, wading, swimming, diving, surfing and water skiing. The chart below provides an overview of the guidance used to assess the status (support or impaired) of the *primary contact recreational use*. Excursions from criteria due to natural conditions are not considered impairment of use.

Variable	***Support*** Criteria are met, no aesthetic conditions that preclude the use	***Impaired*** Frequent or prolonged violations of criteria and/or formal bathing area closures, or severe aesthetic conditions that preclude the use
Bacteria (MDPH 2002b) Minimum Standards for Bathing Beaches State Sanitary Code (MADEP 1996)	At "public bathing beach" areas: Formal beach postings/advisories neither frequent nor prolonged during the swimming season (the number of days posted or closed cannot exceed 10% during the locally operated swimming season). Other waters: Samples* collected during the primary contact season must meet criteria. Shellfish Growing Area classified as "Approved" by DMF.	At "public bathing beach" areas: Formal beach closures/postings >10% of time during swimming season (the number of days posted or closed exceeds 10% during the locally operated swimming season). Other waters: Samples* collected during the primary contact season do not meet the criteria.
Aesthetics (MADEP 1996) - *All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance* [growth or amount] *species of aquatic life*		
Odor, oil and grease, color and turbidity, floating matter	Narrative "free from" criteria met or excursions neither frequent nor prolonged, BPJ.	Narrative "free from" criteria not met - objectionable conditions either frequent and/or prolonged, BPJ.
Transparency (MDPH 1969)	Public bathing beach and lakes – Secchi disk depth ≥1.2 meters (≥ 4') (minimum of three samples representing critical period*).	Public bathing beach and lakes - Secchi disk depth <1.2 meters (< 4') (minimum of three samples representing critical period*).
Nuisance organisms	No overabundant growths (i.e., blooms or dense/very dense biovolume of non-native macrophytes) that render the water aesthetically objectionable or unusable*, BPJ.	Overabundant growths (i.e., blooms or dense/very dense biovolume of non-native macrophytes) rendering the water aesthetically objectionable and/or unusable*, BPJ.

*Data sets to be evaluated for assessment purposes must be representative of a sampling location (minimum of five samples per station recommended) over the course of the primary contact season. Samples collected on one date from multiple stations on a river are not considered adequate to assess this designated use. An impairment decision will not be based on a single sample (i.e., the geometric mean of five samples is <200 CFU/100mL but one of the five samples exceeds 400 cfu/100mL). The method detection limit (MDL) will be used in the calculation of the geometric mean when data are reported as less than the MDL (e.g., use 20 cfu/100mL if the result is reported as <20 cfu/100mL). Those data reported as too numerous to count (TNTC) will not be used in the geometric mean calculation; however frequency of TNTC sample results should be presented.

Secondary Contact Recreational Use

This use is suitable for any recreation or other water use in which contact with the water is either incidental or accidental. These include, but are not limited to, fishing, boating and limited contact incident to shoreline activities. Following is an overview of the guidance used to assess the status (support or impaired) of the *Secondary Contact Use*. Excursions from criteria due to natural conditions are not considered impairment of use.

Variable	***Support*** Criteria are met, no aesthetic conditions that preclude the use	***Impaired*** Frequent or prolonged violations of criteria, or severe aesthetic conditions that preclude the use
Fecal Coliform Bacteria (MADEP 1996)	Other waters: Samples* collected must meet the Class C or SC criteria.	Other waters: Samples* collected do not meet the Class C or SC criteria.
Aesthetics (MADEP 1996) - *All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance* [growth or amount] *species of aquatic life*		
Odor, oil and grease, color and turbidity, floating matter	Narrative "free from" criteria met or excursions neither frequent nor prolonged*, BPJ.	Narrative "free from" criteria not met - objectionable conditions either frequent and/or prolonged*, BPJ.
Nuisance organisms	No overabundant growths (i.e., blooms or dense/very dense biovolume of non-native macrophytes) that render the water aesthetically objectionable or unusable*, BPJ.	Overabundant growths (i.e., blooms or dense/very dense biovolume of non-native macrophytes) rendering the water aesthetically objectionable and/or unusable*, BPJ.

*Data sets to be evaluated for assessment purposes must be representative of a sampling location (minimum of five samples per station recommended) over time. Waters shall not exceed a geometric mean of 1000 cfu/100 ml, nor shall 10% of the samples exceed 2000 cfu/100 ml. Samples collected on one date from multiple stations on a river are not considered adequate to assess this designated use.

Aesthetics Use

All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life. The aesthetic use is closely tied to the public health aspects of the recreational uses (swimming and boating). Below is an overview of the guidance used to assess the status (support or impaired) of the *aesthetics use*.

Variable	***Support*** Narrative "free from" criteria met	***Impaired*** Objectionable conditions frequent and/or prolonged
Odor, oil and grease, color and turbidity, floating matter	Narrative "free from" criteria met or excursions neither frequent nor prolonged*, BPJ.	Narrative "free from" criteria not met - objectionable conditions either frequent and/or prolonged*, BPJ.
Nuisance organisms	No overabundant growths (i.e., blooms) that render the water aesthetically objectionable or unusable, BPJ.	Overabundant growths (i.e., blooms and/or non-native macrophyte growth dominating the biovolume) rendering the water aesthetically objectionable and/or unusable, BPJ.

IX. Reporting on Massachusetts Waters

Massachusetts Summary of Water Quality (305b) Reports

Massachusetts published 305(b) *Summary of Water Quality* reports annually from 1977-1979 and biennially from 1982 through 2000. These reports presented an overview of the monitoring program, the assessment methodology and, for those waters assessed, the number of stream miles or lake and coastal area supporting their designated uses. The earlier 305(b) reports included individual segment-by-segment watershed summaries as well as the statewide use support status. In addition, an attempt was made to compile pertinent information pertaining to the quality of the states' wetlands and groundwater resources. Finally, selected statewide water quality issues of concern, such as acid precipitation or mercury contamination, were discussed in limited detail.

In 1988, the EPA introduced a new automated data management system to store the results of water quality assessments and manage new assessment information. By the time of the 1992 reporting cycle Massachusetts was utilizing this automated database, known as the Waterbody System (WBS), to improve consistency in determining use support and to compile use-support information statewide. Because the individual watershed segment-by-segment assessments were stored in the WBS, this detailed information was no longer included in the annual 305(b) paper report. Rather, an electronic version of the WBS reflecting the most recent assessment information was included as part of the Section 305(b) package submitted to the EPA. Beginning with the 1994 report (actually published in 1995) only the statewide summaries were presented in the hard copy reports and the individual segment information was provided in the "electronic update." This arrangement proved to be very effective for reporting basic statewide information to the EPA and Congress. However, it was not a good mechanism for communicating information to agency personnel and other interested parties in order to prioritize waters for remedial actions or protection measures. To meet the increasing demand for data and information to support the Massachusetts water quality management programs at the state and local level, the Department now publishes individual watershed assessment reports that supplement the traditional 305(b) reporting process.

Watershed Assessment Reports

The Department typically prepares individual watershed assessment reports during the third year of its five-year watershed assessment and management cycle. These reports are a synthesis of many kinds of information pertaining to the ecological and regulatory status of the water resources in the respective watersheds. Each report presents a description of the geophysical characteristics and land uses in the watershed along with information on wastewater discharges, water withdrawals and other issues affecting water quality and ecosystem integrity. The main feature of the watershed assessment report is a summary of the current water quality data and information used to assess the status of the designated uses as defined in the Water Quality Standards. This includes a description and results of the monitoring activities carried out by the Department in the previous year ("Year 2") as well as documentation of external sources of data utilized in the assessments. Use-support determinations are made for each waterbody segment for which adequate data and information are available. Finally, the watershed reports include segment-by-segment recommendations for further actions, such as additional monitoring to confirm use-support decisions or identify causes and sources of impairment or steps to be taken to correct known problems. Report preparation is continuing sequentially as an integral step in the watershed management cycle. Copies of the watershed assessment reports are distributed to the EPA in partial fulfillment of the State-EPA Performance Partnership Agreement (PPA) and to other interested parties. In addition, the published reports can be found at **http://www.state.ma.us/dep/brp/wm/wqassess.htm**.

Special Reports and Technical Memoranda

Results of site-specific or project-specific targeted monitoring may be described in individual technical reports or memoranda. Depending upon the content, technical memoranda may be appended to more comprehensive watershed assessment reports, or they may serve as "stand-alone" documents. Often the results of biomonitoring efforts, such as benthic macroinvertebrate or fish community assessments, are reported in technical memoranda. As an example, the results of the pilot project to locate contamination sources will be documented in a "Bacteria Source Identification Report" that includes site selection methods, site characterization, analytical results, recommendations for listing or de-listing (pursuant to section 303d), and recommendations for eliminating sources of contamination.

Massachusetts (303d) Lists of Impaired Waters

Section 303(d) of the CWA requires states to periodically identify and list those waterbodies for which existing controls on point and nonpoint sources of pollutants are not stringent enough to attain or maintain compliance with applicable surface water quality standards. Furthermore, the CWA specifies that the states calculate, for each impaired waterbody, the maximum amount of pollutant that the water can receive without violating water quality standards. Once derived, this capacity for a water to accept a quantity of pollutant without impairing its uses, expressed as a total maximum daily load or TMDL, is apportioned among point discharges and nonpoint sources while allowing for background levels and a margin of safety. Thus, the 303(d) List identifies and prioritizes waters in need of further clean-up and the TMDL process provides the mechanism for allocating allowable pollutant loads.

Regulations governing the preparation of the 303(d) List, first issued in 1978 and amended once in 1985 and again in 1992, specify that states must submit a list of impaired waters to the EPA on or before April 1 of even-numbered years. Furthermore, the regulations require that states consider all "existing and readily available water quality-related data and information" when compiling their lists. This includes the Summary of Water Quality (305b) Report, NPDES discharge monitoring records, DPH fish consumption advisories, data from other federal and state agencies, and citizen monitoring data. States must include on the lists the specific pollutant(s) or stressor(s) causing impairment (if known) and a priority ranking for completing TMDLs. Finally, the draft list must be made available to the public for their review and comment before a final list is submitted to the EPA for approval. Massachusetts developed 303(d) Lists in 1992, 1994, 1996, and 1998. Each subsequent revision incorporated new information for those waters that had been assessed since the previous version was published but did not represent a completely new statewide listing. Each list was subjected to public review and comment and subsequently approved by the EPA.

The Integrated List of Massachusetts Waters

In 2001 and 2002 the EPA issued two new sets of guidance aimed at improving states' monitoring and assessment programs and making data and information more available to the public. The *Consolidated Assessment and Listing Methodology* ("CALM Document") provided guidance to the states on how to update and clarify the decision making process for assessing the attainment of water quality standards. In addition, the EPA released guidance to the states for the preparation of an *Integrated List of Waters* that would meet the reporting requirements of both sections 305(b) and 303(d) of the CWA. The integrated list format, which was adopted by Massachusetts for the 2002 and 2004 assessment and listing cycles, allows states to provide the current status of all their assessed waters in a single multi-part list. In doing so, each water body or segment thereof is placed in one of the following five categories:

1) Unimpaired and not threatened for all designated uses;
2) Unimpaired for some uses and not assessed for others;
3) Insufficient information to make assessments for any uses;
4) Impaired or threatened for one or more uses but not needing a TMDL; and
5) Impaired or threatened for one or more uses and requiring a TMDL.

Thus, the waters listed in Category 5 are the 303(d) List and, as such, are reviewed and approved by the EPA. The remaining four categories are submitted in fulfillment of the requirements under Section 305(b), essentially replacing the old 305(b) Report format.

X. Programmatic Evaluation

A high priority of the Department is assuring that "programmatic evaluation" occurs for all aspects of the monitoring design. In consultation with the EPA, the DWM prepares QAPPs for all the monitoring efforts, which are submitted to EPA for review. A major aspect of the QAPPs is the use of internal audits that the DWM QA/QC Officer conducts – including reviews and first observations of field and laboratory procedures, reviews of QA protocols, reviews and evaluations of all data (including QC data on replicates, blanks, and spikes), evaluations of data assessment procedures, and finally, reviews of how well the program meets the monitoring objectives. Routine changes and additions are recommended and incorporated into future monitoring cycles.

XI. General Support and Infrastructure Planning

Personnel and monetary resources will be needed to implement new monitoring programs, and to continue existing programs, as described in this strategic monitoring plan. The requirements of the individual monitoring elements are briefly discussed below, and are summarized in the accompanying table.

Resource Requirements for Status (Assessment) and Targeted Monitoring

Approximately 30 FTEs would be required for field sample collection and processing, and roughly 7,500 laboratory analyses would be needed, to complete use assessments in approximately five watersheds per year in accordance with the rotating five-year cycle. To support this assessment schedule, it is critical that the monitoring program include a bioassessment staff at a recommended level of five (5) benthic macroinvertebrate biologists, three (3) microbiologists (algae, chlorophyll, bacteria), three (3) fish biologists, and one (1) wetlands ecologist. Additional time for field preparation and planning, laboratory analyses, data management, GIS, and report preparation is presented under "Additional Monitoring Resources" below. In order for the Department to make use of data from volunteer groups, a volunteer monitoring liaison will be needed to review QAPPs, review data from external sources to confirm validity and completeness, and make recommendations for their use in watershed assessments.

Because the various targeted monitoring programs are issue-, site-, and basin-specific, resource requirements for these components of the Department's monitoring program are difficult to predict in advance. With the exception of monitoring to support the TMDL Program, it is assumed for planning purposes that the resources necessary for targeted monitoring are included in the total FTE and sample analytical requirements listed above for the use assessment monitoring.

Increasing demand for monitoring support for TMDL development over the next several years will likely necessitate the procurement of additional resources. Through a contractual

arrangement with the consultants CH2M Hill, the Department developed a work-load model that can project the resources needed, including monitoring support, to meet the TMDL Program objectives and commitments. Using the 2002 303(d) list of impaired waters to tally the number of TMDLs that need to be completed over the next twelve years the work-load model predicted that 6 FTE and $192,360 in other direct costs would be needed in each of those years to provide sufficient monitoring support for the TMDL effort. This analysis assumes that a moderate level of effort will be required for each TMDL, which is reasonable for the TMDLs that can be accomplished using readily available models and standardized protocols. It is likely that resource needs will be greater for those TMDLs requiring new state-of-the-art modeling techniques or other innovative approaches; however, the monitoring effort needed to support these new analyses cannot be defined at this time.

Resource Requirements for Contaminant Load Trends

It is estimated that two (2) FTEs would be needed for water-quality sample collection, with additional costs and staff time needed for field preparation, laboratory analyses, and data analysis and management (covered below). The development of an enhanced fixed-station monitoring program utilizing automatic metering of dissolved oxygen, pH, temperature and conductivity at these nineteen stations is currently under consideration. Resources that would be needed to support this program are estimated in Appendix 2.

General Monitoring Support

The following resources are needed to support all of the monitoring elements described above.

Field Technical Support

Field monitoring support staff (2 FTE) are required for instrument maintenance and calibration; prepration of calibration standard solutions; purchase, storage and maintenance and repair of field equipment and supplies; maintenance of the Department's laboratories and associated equipment, supplies and reagents; and scheduling of vehicles and boats. The Department is investigating the need for a single Lab Manager position at the Worcester facility for compliance with all regulations and safety procedures.

Data Managers

Seven (7) FTEs are needed for database development, data management computer program development, assistance to field staff with data analysis and report preparation, assistance with special projects, and updating a Department web page with the most current water quality conditions of surface waters (it would be extremely valuable for the public to have access to DWM data in a fairly routine and timely manner – the exact nature of data sets would have to be determined, but could include such things as bacteria levels in selected waterbodies, results of rapid bioassement protocol efforts, etc.). DWM data management efforts would be required for all the following data:

- water chemistry/hydrology
- benthic macroinvertebrate and other biological community structure and habitat
- River segments
- Lake segments
- Coastal and marine segments
- Waterbody System, Assessment Database, or equivalent for 305b/303d reporting
- Sediment chemistry
- Tissue chemistry

- GIS

QA/QC Oversight

Approximately 3.0 FTEs will be required to assist field staff in study design; preparation of QAPPs; interpretation of QC data on field and laboratory splits, blanks, and spikes; preparation of QC samples for use in assessing laboratory analytical capabilities related to accuracy and precision; and development of the overall QA plan for each element of the DWM field operation. It is recommended that one FTE be a statistician to assist with monitoring program design and data analysis.

Geographic Information Systems

Approximately 0.5 FTE will be required for supporting staff with geographic data display, management of GIS databases, and preparation of maps depicting DWM monitoring-related information and data, as well as standard GIS coverages.

Analytical Laboratory Support

Funding will be needed to support full-time and seasonal personnel at the Department's Wall Experiment Station (WES) and for the purchase of monitoring equipment and supplies for all of the monitoring elements covered by this plan.

Summary of Resource Needs for the Department's Comprehensive Monitoring Program

RESOURCE	**ANNUAL PERSONNEL (FTE)***	**ANNUAL COST***
Assessment and Targeted Monitoring		
Water quality monitoring staff	14.0 *(10.0)*	$1,190,000 *($850,000)*
Benthic biologists	5.0 *(2.0)*	$425,000 *($170,000)*
Microbiologists	3.0 *(2.0)*	$255,000 *($170,000)*
Fish biologists	3.0 *(1.0)*	$255,000 *($85,000)*
Wetlands ecologist	1.0 *(1.0)*	$85,000 *($85,000)*
Volunteer monitor liaison	1.0 *(1.0)*	$85,000 *($85,000)*
Seasonal field staff	3.0	$255,000
TMDL monitoring staff	6.0 *(6.0)*	$510,000 *($510,000)*
TMDL monitoring equipment	--	$192,360 *($192,360)* **
Total personnel and cost	**36.0 *(23.0)***	**$3,252,360 *($2,147,360)***
Continuous Fixed-site Monitoring for Contaminant Load Trends		
Monitoring staff	2.0 *(2.0)*	$170,000 *($170,000)*
Total cost	--	**$170,000 *($170,000)***
General Monitoring Support		
Field technical support staff	2.0 *(1.0)*	$170,000 *($85,000)*
Data management staff	7.0 *(4.5)*	$595,000 *($382,500)*
QA/QC staff/statistician	3.0 *(2.0)*	$255,000 *($170,000)*
GIS staff	0.5	$42,500
Total personnel	**12.5 *(7.5)***	**$1,062,500 *($637,500)***
Monitoring Equip/Supplies	--	$40,000 *($10,000)*
Laboratory support (8 FTE)	--	$680,000 *($595,000)*

Seasonal/ongoing laboratory	--	$75,000
Total cost	--	**$1,857,500** ***($1,242,500)***
Drinking Water Program		
Drinking Water staff	0.6 *(0.6)*	$51,000 *($51,000)*
Laboratory services	--	$1,516,568 *($1,516,568)*
GRAND TOTAL	**51.1 FTE** ***(33.1 FTE)***	**$6,847,428** ***($5,127,428)***

* Existing program shortfalls are provided in italics and parentheses.
** Costs for vehicles, flow meters, temperature meters, current meters, bacterial analyses, and water chemistry analyses.
Note:
1) Above estimates do NOT include resources for marine monitoring (assumes CZM and DMF lead)
2) Above estimates do not include office equipment and office space.

With a total shortfall approximating twice the currently available resources, it is clear that the Monitoring Strategy will need to be implemented in phases as new funding becomes available. The following table summarizes by program element the long-term and immediate personnel resources needed to implement the plan.

PROGRAM ELEMENT	PRIORITY	LONG-TERM NEED (FTE)/(dollars)	EXISTING STAFF (FTE)	EXISTING STAFF (% of need)	IMMEDIATE NEED (FTE)/(dollars)
Assessment Monitoring	High	27 ($2,295,000)	13	48%	7 ($595,000)
TMDL Monitoring	High	6 ($510,000)	0	0%	6 ($510,000)
Fixed-site Monitoring	Medium	2 ($170,000)	0	0%	0
Probabilistic Monitoring	Low	3 ($ 255,000)	0	0%	0
Support Staff	High	12.5 ($1,062,500)	5	40%	2 ($170,000)
Drinking Water	Medium	0.6 ($51,000)	0	0%	0
TOTAL	**--**	***51.1 ($4,343,000)***	***18***	***36%***	***15 ($1,275,000)***

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APPENDIX 1

Ongoing Water Monitoring in Massachusetts by State Agencies and Programs

(A revised summary of the USGS findings from 2001)

As part of the development of the water quality network design for Massachusetts the USGS reviewed and summarized several ongoing water quality monitoring programs administered by various agencies and organizations. The following brief descriptions of selected programs are adapted from the USGS final report (DeSimone, Steeves and Zimmerman, 2001) and provide the context for how these activities are used in a comprehensive statewide water quality monitoring strategy.

Several agencies in addition to the Department support routine, environmental water quality monitoring (refer to the table below). Others monitor for compliance with specific regulations, such as monitoring by the Department's Drinking Water Program for public-water supply compliance with drinking-water-quality regulations. Some agencies support water-quality studies through the administration of special programs and grants for relatively short-term studies; these agencies include the Massachusetts Coastal Zone Management Office (MCZM) and the Lakes and Ponds Program of the Department of Conservation and Recreation (MDCR). The MCZM's Marine Monitoring and Research Program assesses coastal wetlands and studies the effects of contaminated sediment, for example. The MDCR Lakes and Ponds Program performs studies of water-quality problems related to occasional low flushing rates in lakes in some state parks. The MDCR, through its Division of Watershed Management Division (DWM), also collects a great deal of environmental data in its extensive fixed-site network in the Quabbin Reservoir, Ware River, and Wachusett Reservoir watersheds. The following discussion provides more detail on some of the programs that provide data that are, or could be, useful to the Department when performing watershed assessments.

The MDCR/DWM maintains a fixed-site network that monitors drinking-water sources used by much of the metropolitan Boston area. Samples are collected from many tributary streams and the Quabbin and Wachusett reservoirs at frequencies that vary depending on the water-quality constituent monitored. Sampling frequency ranges from daily for Quabbin Reservoir (although samples are sometimes collected twice daily at the outlet to the aqueduct), to biweekly at tributary sites. Sampling parameters are primarily indicator bacteria and nutrients (nitrogen and phosphorus species). Monthly reservoir depth profiles for temperature, pH, dissolved oxygen, and specific conductance also are made in Quabbin Reservoir from April through November. In the Wachusett watershed, indicator bacteria samples are collected generally daily in the reservoir and weekly in tributaries; nutrients are sampled weekly in tributaries; and reservoir profiles are conducted monthly. Field parameters, such as temperature, dissolved oxygen, pH, and specific conductance are measured at the time of sample collection. Sampling also is conducted for *Giardia*, *Cryptosporidium*, and phytoplankton in the Quabbin and Wachusett watersheds and, on occasion, in Quabbin, a number of other water-quality constituents, such as iron, color, turbidity, and total suspended solids are measured. In addition to the water chemistry and bacteria monitoring, a MDCR/DWM biomonitoring program conducts macroinvertebrate sampling at about 12 to 24 fixed sites in tributary streams. The macroinvertebrate data are used as integrated measures of stream quality and changes in quality over time.

The MCZM administers a number of projects and programs, under various stages of development, that now, or will in the future, provide data and information pertaining to the status of Massachusetts' coastal wetlands and water bodies. Working with a number of different partners, the MCZM has developed and implemented multi-metric biotic indices to examine the

integrity of salt marshes. The goals of this program are to:

1. To develop and evaluate techniques for assessing the ecological integrity of coastal wetlands in order to:
--Inventory of wetland sites in specific areas;
--Report on wetland condition;
--Identify degraded wetland sites;
--Evaluate restoration potential; and
--Monitor restoration response.
2. To transfer techniques to interested parties, with an emphasis on training and assisting volunteers. 3. To convey the assessment methods and results to coastal wetland decision-makers.

In its wetlands assessment program, CZM has worked on three types of projects to date. From 1995-2000, assessment efforts were focused on the development of biotic indices for coastal tidal wetlands (salt marshes). Three projects were completed: Waquoit Bay 1995-1997, North Coastal and Ipswich Watersheds 1998-1999, and Cape Cod Bay 1999-2000. Surveys of plant and macro-invertebrate communities at selected salt marsh study sites were examined within the context of human disturbance indicators, including nitrogen concentrations, impervious area and land use. Plant Community Index and Invertebrate Community Index scores indicate a definite trend towards decreasing biotic integrity with increasing land use intensity.

Massachusetts CZM Programs are also underway to assess both the magnitude and extent of habitat and biodiversity impacts from invasive species. The Mass Bays Program, CZM, and MIT Sea Grant have conducted Rapid Assessment Surveys in 2000 and 2003 to assess the distribution of marine invasive species on permanently floating docks and piers in state coastal waters. The surveys have also included an assessment of all native species, including the presence or absence and rough abundance. Surveys are planned to continue at roughly three year intervals, depending on funding. Basic water quality parameters are collected at each survey site. A standardized protocol for this Rapid Assessment is being prepared to guide other similar assessments in the region. The Mass Bays Program, through its regional partner, Salem, Sound Coastwatch, has initiated and trained citizen volunteers to monitor similar permanently floating habitats for marine invasive species on a year round basis, beginning in 2003. A protocol for citizen monitoring efforts for marine invasive species is also being developed.

CZM is also initiating programs to assess the extent of marine habitats as part of a Marine Habitat Management strategy. The Marine Habitat Management strategy at CZM includes the development of a marine habitat management plan, marine habitat monitoring strategy and the promotion and initiation of seafloor habitat mapping. CZM is administrating a cooperative agreement with the United States Geological Survey to map the seafloor environment, including substrate type and topography, in Massachusetts Bay and Boston Harbor. These maps will provide the foundation for the identification and quantification of subtidal marine habitats and will be fundamental for the development of a marine habitat monitoring strategy. The distribution and abundance of seagrass is systematically quantified through the Massachusetts Department of Environmental Protection Wetland Conservancy Program; therefore, to enhance DEP's sea grass mapping program and initiate efforts to develop a strategy to monitor marine habitats, the emphasis of marine habitat monitoring is on the distribution and health of sea grasses.

The MCZM is an active participant in the EPA's National Coastal Assessment ("Coastal 2000") that employs a probabilistic monitoring design and common set of indicators among the twenty-four coastal states to survey the ecological condition of the Nation's coastal resources,

estuaries and offshore waters. The Department is interested in becoming involved with this program by investigating ways of maximizing the use of this probabilistic marine monitoring program in the assessment of coastal waters for the development of the Integrated List.

Finally, as part of the Coastal Nonpoint Pollution Control Plan (6217), CZM has developed a coastal monitoring strategy, which outlines an approach for evaluating Massachusetts's success in implementing nonpoint management measures and effecting positive changes in water quality. CZM is developing a protocol for conducting watershed scale assessments through a pilot monitoring effort in the Parker watershed. This effort includes an assessment of land use status and trends (percent impervious surface and development), an inventory of potential nonpoint pollution sources and management measures (septic systems, agriculture operations, and riparian and wetland buffer loss), as well as a water quality data mining effort that includes over 20 data sets. In order to facilitate this and other NPS assessment efforts, CZM is developing a set of GIS based tools to assist water quality managers in storing, organizing, and analyzing water quality data, and evaluating these data in the context of land use conditions. These tools will include a data entry template, filter and import utilities, and spatial statistics tools. The expected completion date of the Parker assessment and the GIS Water Quality Tool Pack is the Fall of 2004.

The MWRA monitors water quality in Boston Harbor and its tributaries to support outfall siting and combined sewer overflow (CSO) management decisions, as well as to demonstrate the effectiveness of ongoing pollution control efforts. In addition, MDCR/DWM, working for the MWRA, monitors for potential beach contamination by bacteria in summer that may cause the beaches to be closed. Monitored areas include the Charles, Neponset, and Mystic Rivers, Dorchester Bay, and the Inner Harbor. Water quality conditions in these areas are determined by regular sampling and measurements of algae, suspended solids, turbidity, dissolved oxygen, and nutrients. The health of fish, shellfish, and other harbor animal communities also is routinely monitored. The stream water-quality data collected by MDCR and MWRA include many of the sampling parameters needed to assess compliance with State water-quality standards. Thus, these data would be useful in determining use-support of the sampled stream reaches. However, the spatial distribution of sampling sites is limited, and the targeted site-selection approach would make it difficult to extrapolate monitoring results to unsampled streams. The MDCR and MWRA data, particularly from sites in the relatively pristine Quabbin watershed, however, could be used to characterize background or unimpaired conditions in Massachusetts streams.

The Massachusetts Highway Department (MHD) collects water-quality samples primarily from ground water from municipal and private water supplies statewide. This monitoring focuses on contamination associated with road-salt constituents of highway runoff, such as sodium, calcium, and chloride. Although this network might overlap with some fixed sites in a proposed surface-water quality monitoring network, the limited range of water-quality constituents indicates that this program would provide only ancillary data for other monitoring objectives.

Two programs in the Massachusetts Department of Fish and Game (DFG) provide data used by the Department for assessment purposes are administered by the Division of Marine Fisheries (DMF) and the Division of Fisheries and Wildlife (DFW). The DMF monitoring program collects environmental data at some 350 sites in the coastal waters of Massachusetts. Primary data collection efforts focus on bacterial contamination of shellfishing beds. These data have been used for assessing designated uses of coastal waters for the State’s 305(b) report and will continue to be very useful for this purpose. The distribution of sampling sites is likely to be based on a targeted approach, however, such that additional data or alternative approaches would be needed to develop a comprehensive assessment of designated use of all coastal

waters as defined for 305(b) purposes. The DFW conducts fish community surveys throughout the State in accordance with a five-year rotating basin cycle, and monitors game fish populations in Quabbin and Wachusett watersheds. These data support use determinations for aquatic life in sampled streams, but would be difficult to extrapolate to unsampled streams.

In addition to the State agencies with responsibilities for monitoring water quality, there are at least 100 local volunteer groups that are concerned with some aspect of water quality. These groups, many of which are associated with the Massachusetts Water Watch Partnership, generally are distributed throughout the State and may focus their efforts on streams, lakes or ponds, and coastal habitats. Their activities may range from lobbying to occasional monitoring to maintaining a full-time professional staff. These volunteers can serve as an important part of a statewide water-quality-monitoring network, by collecting reconnaissance or higher-level data, by compiling information on local impairments and pollution sources, and by otherwise supplementing agency programs.

Ongoing water-quality monitoring in Massachusetts by State agencies and programs

[Adapted from DeSimone et al., 2001. Agencies included in this table were contacted during January through March 2000; --, not applicable]

Agency	Program	Description and Focus of Monitoring Program	Sampling Parameters	Type of Sampling Site	Duration of Sampling	Geographic Area Of Activity
Cape Cod Commission	Water Resources Office	Site-specific assessment projects	Vary by project	Vary by project	Short term	Cape Cod
Coastal Zone Management	Coastal Water Quality/ Massachusetts Bays	Wetlands health	Dissolved oxygen, pH, nutrients, salinity, macroinvertebrates, vegetation, birds	Fixed	Short term	Coastal areas
	Marine Monitoring and Research	Wetlands assessments; contaminated sediments	Water chemistry, macroinvertebrates, vegetation, birds	Variable	Short term	Coastal areas
Department of Environmental Conservation and Recreation	Water Resources/Data Collection and Analysis	Cooperative programs with USGS	Vary by program	Fixed and variable	Short and long term	Varies by program
	Water Resources/Lakes and Ponds	Lakes and ponds in some State parks	Vary by issue	Variable	Short term	Statewide
	Watershed Management/ cooperatively with Massachusetts Water Resources Authority	Drinking-water protection	Nutrients, alkalinity, hardness, bacteria and other pathogens, and macroinvertebrates	Fixed	Long term	Quabbin Reservoir, Ware River, and Wachusett Reservoir watersheds
	Watershed Management	Pubic-beach monitoring	Bacteria	Fixed	Long term, summer	Public beaches
Department of Environmental Protection	Resource Protection/ Drinking Water	Compliance of public-water suppliers with drinking-water regulations	Drinking-water Contaminants	Fixed	Long term	Statewide
	Resource Protection/ Watershed Management	Clean Water Act monitoring and assessment;	Water chemistry; benthic macroinvertebrates; lake vegetation; fish toxics; others	Variable	Short term	Statewide, but focused in “Year 2” basins

ongoing water-quality monitoring in Massachusetts by State agencies and programs – (Concluded)

Agency	Program	Description and Focus of Monitoring Program	Sampling Parameters	Type of Sampling Site	Duration of Sampling	Geographic Area of Activity
Department of Fish and Game	Fisheries and Wildlife	Fish community surveys; special studies related to game fish population	Fish community	--	--	--
	Marine Fisheries	Fish and shellfish health	Dissolved oxygen, temperature, bacteria	Fixed	Long term	Coastal areas
Massachusetts Highway Department	Research and Materials	Highway runoff and public-water supplies	Road-salt constituents	Fixed	Variable	Statewide
Massachusetts Water Resources Authority		Water quality in Boston Harbor and tributaries	Sewage contaminants (nutrients, bacteria, others)	Fixed	Long term	Boston Harbor and tributaries; beaches

APPENDIX 2

Proposed Automated Continuous Monitoring Network

Estimated Capital and Maintenace Costs: Eighty-six (86) USGS stream flow stations that are presently in use would be continued. DEP, and several other state agencies, have a cooperative agreement to maintain these sations. DEP's annual cost share in 2002 was $152,485.

The establishment of 19 new water quality stations and annual maintenance of them is significant however, it is more cost-effective than collecting samples on an on-going basis by limited personnel. Although additional discussions need to take place relative to the planning, design, installation of the gages, as well as, the cost of data management, reporting, and establishment of appropriate quality control procedures (including on-going maintenance issues and budget), the preferred option would be to plan, install, and maintain 19 continuous data recorders that could collect data on a short time frame (could be minutes, days, or weeks). These recorders would transmit real-time data from each site and make it available on the web for access by DEP staff, watershed organizations, consultants, and others. Very preliminary cost estimates would include the following:

ITEM	Cost/site	Total Cost
1. Continue existing Flow stations		**$**152,485/yr[1]
2. Equipment Purchase (temperature, DO, pH conductivity probes)	$12,900/site	$245,100/19 sites
3. Installation (includes calibration)	$4,000/site	$76,000/19 sites
4. Operation and maintenance	$4,100/site	$77,900/19 sites
5. Data Publication	N/A	$ 10,000/19 sites
6. Database Management	N/A	$53,200/19 sites

First year capital costs: $462,200
(equipment purchase, installation, O&M, data publication, database management)

Annual Out year Costs: $155,933
(O&M, data publication, database management – assumes 5% inflation rate each year)

Annual Out year Costs: $168,515
(Stream flow gage cost share – assumes 5% inflation rate each year)

[1] DEP 2002 cost share

APPENDIX 3

Drinking Water Program-Related Monitoring: Ground water and Surface Water Laboratory Services

1) Raw water quality monitoring at reservoirs and tributaries: to look at trends in organics, inorganics and microbial contamination

173 active reservoirs

organics	=	1,100.00
inorganics	=	180.60
e-coli	=	55.00

1,335.60 x 173 reservoirs = $231,059

x 173 tributaries = $231,059

= **$462,118**

2) Long-Term II Enhanced Surface Water Treatment Rule: to sample for e-coli at small systems with reservoirs to help them meet Federal requirements

34 reservoirs serving under 10,000

e-coli	=	55.00

55.00 x 34 = **$1,870**

3) Disinfection Byproducts Rule: sampling for color, UV254, and TOC at small systems with reservoirs with slow sand filtration to help them meet Federal requirements

7 reservoirs serving under 10,000 with slow sand filtration

color	=	9.10
UV254	=	25.20
TOC	=	28.70

63.00 x 7 = **$441**

4) raw water quality testing at public drinking water wells with treatment (disinfection): to provide data for water suppliers to pro-actively look at treatment and to develop source protection strategies – may also help with the establishment of Total Maximum Daily Loads (TMDL)

200 ground water systems that treat = 736 wells

organics		1,100.00
inorganics	=	180.60
e-coli	=	55.00

1,335.60 x 736 wells = **$983,002**

5) Disinfection Byproducts Rule: sampling for color, iron and UV254 at ground water systems to help them meet the Federal requirements

1,593 ground water systems (242 municipal; 202 non-municipal; 248 NTNC; 901 TNC)

color	=	9.10	
iron	=	9.10	
UV254	=	25.20	
		43.40 x 1593 wells	= **$69,137**

TOTAL $1,516,568